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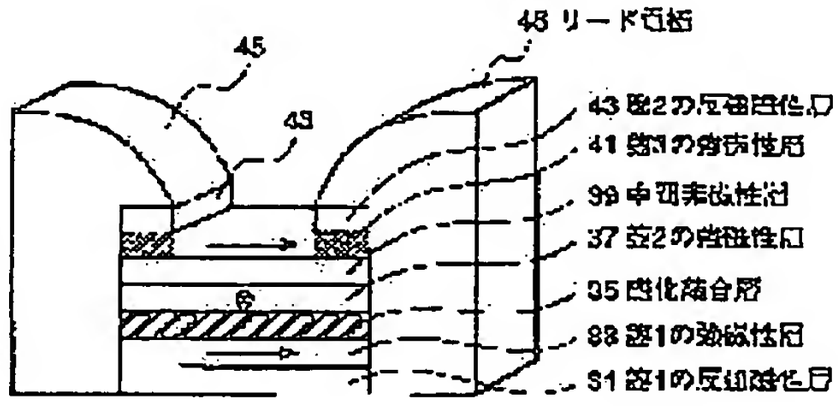
(54) MAGNETORESISTIVE EFFECT ELEMENT, MAGNETORESISTIVE EFFECT HEAD, MAGNETIC REPRODUCING DEVICE AND MAGNETIC LAMINATED BODY

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an inexpensive and high performance magnetoresistive effect element of a thin film which is made suitable for a magnetic reproducing system such as a magnetic reproducing head necessitating a narrow gap and a hard disk drive.
SOLUTION: An intermediate layer 35 in which the magnetization of a ferromagnetic layer is connected with the direction of 90° is inserted into a clearance between pin layers 33 and 37, so that heat treatment for forming the mono-magnetic domain of a free layer 41 by a anti-ferromagnetic body 43 and heat treatment for fixing the magnetization of the pin layer can be simultaneously operated. Thus, it is possible to unnecessitate any difference between the blocking temperatures of the anti- ferromagnetic body 43 brought into contact with the free layer 41 and that of the anti-ferromagnetic layer 31 brought into contact with the pin layer 33, and to select the anti-ferromagnetic layer having high interchangeable connecting magnetic field and a high blocking temperature. Also, it is possible to widen an allowable range for the distribution of the interchangeable connecting magnetic field, to realize the thin film of the anti-ferromagnetic layer, and to apply this element to a magnetic reproducing head requiring a narrow gap.



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CLAIMS

[Claim(s)]
[Claim 1] The magnetization binder course by which laminating formation was carried out with the 1st ferromagnetic layer equipped with magnetization of the 1st direction, and said 1st ferromagnetic layer, The 2nd ferromagnetic layer in which laminating formation is carried out with said 1st ferromagnetic layer through said magnetization binder course, and magnetization association is carried out by said magnetization binder course with said 1st ferromagnetic layer and which is equipped with magnetization of said 1st direction and the abbreviation rectangular cross direction, The magneto-resistive effect component characterized by having a middle non-magnetic layer and the 3rd ferromagnetic layer to which laminating formation is carried out with said 2nd ferromagnetic layer through said middle non-magnetic layer, and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state.
[Claim 2] Said magnetization binder course is a magneto-resistive effect component according to claim 1 characterized by having the mixed phase film containing two or more sorts of oxides with which the valences of the same metal differ, or the cascade screen which contains the oxide layer from which the valence of the same metal differs more than two-layer.
[Claim 3] The mixed phase film containing two or more sorts of oxides with which the valences of the same metal as the 1st ferromagnetic layer equipped with magnetization of the 1st direction differ, Or the insertion layer by which possessed the cascade screen equipped with the oxide layer from which the valence of the same metal differs more than two-layer, and laminating formation was carried out with said 1st ferromagnetic layer, The 2nd ferromagnetic layer which laminating formation is carried out with said 1st ferromagnetic layer through said insertion layer, and is equipped with magnetization of said 1st direction and the abbreviation rectangular cross direction, The magneto-resistive effect component characterized by having a middle non-magnetic layer and the 3rd ferromagnetic layer to which laminating formation is carried out with said 2nd ferromagnetic layer through said middle non-magnetic layer, and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state.
[Claim 4] The magneto-resistive effect component according to claim 1 or 3 characterized by having the 2nd antiferromagnetism layer by which laminating formation was carried out at the 1st antiferromagnetism layer by which laminating formation was carried out at said 1st ferromagnetic layer, and said 3rd ferromagnetic layer.
[Claim 5] The oxide with which said valences differ is a magneto-resistive effect component according to claim 2 or 3 characterized by consisting of an oxide of Fe and being chosen out of FeO, Fe 3O4, alpha-Fe 2O3, and gamma-Fe 2O3.
[Claim 6] The oxide with which said valences differ is a magneto-resistive effect component according to claim 2 or 3 which consists of an oxide of Cr and is characterized by being chosen out of CrO, Cr 2O3, CrO2 and Cr 2O5, and CrO3 and CrO5.
[Claim 7] The oxide with which said valences differ is a magneto-resistive effect component according to claim 2 or 3 which consists of an oxide of Mn and is characterized by being chosen out of MnO and MnO2.
[Claim 8] It is the magneto-resistive effect component according to claim 1 to 7 which said 2nd ferromagnetic layer is a magnetization free layer from which the direction of said magnetization changes with fluctuation of an external magnetic field, and is characterized by said 3rd ferromagnetic layer being a magnetization fixing layer from which said magnetization direction does not change substantially in the external magnetic field where the magnetization direction of said 2nd ferromagnetic layer changes.
[Claim 9] It is the magneto-resistive effect component according to claim 1 to 7 which said 3rd ferromagnetic layer is a magnetization free layer from which the direction of said magnetization changes with fluctuation of an external magnetic field, and is characterized by said 2nd ferromagnetic layer being a magnetization fixing layer from which said magnetization direction does not change substantially in the external magnetic field where said magnetization direction of said 3rd ferromagnetic layer changes.
[Claim 10] The 1st antiferromagnetism layer and the 1st ferromagnetic layer which is the ferromagnetic layer

which carried out switched connection to said 1st antiferromagnetism layer, and is equipped with magnetization of the 1st direction, Laminating formation is carried out with said 1st ferromagnetic layer through the magnetization binder course by which laminating formation was carried out with said 1st ferromagnetic layer, and said magnetization binder course. The 2nd ferromagnetic layer in which magnetization association is carried out by said magnetization binder course with said 1st ferromagnetic layer and which is equipped with magnetization of said 1st direction and the abbreviation rectangular cross direction, A middle non-magnetic layer and the 3rd ferromagnetic layer to which laminating formation is carried out with said 2nd ferromagnetic layer through said middle non-magnetic layer and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state, The magneto-resistive effect head characterized by providing a magneto-resistive effect component equipped with the 2nd antiferromagnetism layer which carried out switched connection to said 3rd ferromagnetic layer.

[Claim 11] Said magnetization binder course is a magneto-resistive effect head according to claim 10 characterized by having the mixed phase film containing two or more kinds of oxides with which the valences of the same metal differ, or the cascade screen which contains the oxide layer from which the valence of the same metal differs more than two-layer.

[Claim 12] The mixed phase film containing two or more sorts of oxides with which the valences of the same metal as the 1st ferromagnetic layer equipped with magnetization of the 1st direction differ, Or the insertion layer by which the oxide layer from which the valence of the same metal differs possessed the cascade screen by which the laminating was carried out more than two-layer, and laminating formation was carried out with said 1st ferromagnetic layer, The 2nd ferromagnetic layer which laminating formation is carried out with said 1st ferromagnetic layer through said insertion film, and is equipped with magnetization of said 1st direction and the abbreviation rectangular cross direction, The magneto-resistive effect head characterized by providing a magneto-resistive effect component equipped with a middle non-magnetic layer and the 3rd ferromagnetic layer to which laminating formation is carried out with said 2nd ferromagnetic layer through said middle non-magnetic layer, and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state.

[Claim 13] The oxide with which said valences differ is a magneto-resistive effect head according to claim 11 or 12 characterized by consisting of an oxide of Fe and being chosen out of FeO, Fe 3O4, alphaFe 2O3, and gammaFe 2O3.

[Claim 14] The oxide with which said valences differ is a magneto-resistive effect head according to claim 11 or 12 which consists of an oxide of Cr and is characterized by being chosen out of CrO, Cr 2O3, CrO2 and Cr 2O5, and CrO3 and CrO5.

<DP N=0003> [Claim 15] The oxide with which said valences differ is a magneto-resistive effect head according to claim 11 or 12 which consists of an oxide of Mn and is characterized by being chosen out of MnO and MnO2.

[Claim 16] It is the magneto-resistive effect head according to claim 10 to 15 which said 2nd ferromagnetic layer is a magnetization free layer from which the direction of said magnetization changes with fluctuation of an external magnetic field, and is characterized by said 3rd ferromagnetic layer being a magnetization fixing layer from which said magnetization direction does not change substantially in the external magnetic field where the magnetization direction of said 2nd ferromagnetic layer changes.

[Claim 17] It is the magneto-resistive effect head according to claim 10 to 15 which said 3rd ferromagnetic layer is a magnetization free layer from which the direction of said magnetization changes with fluctuation of an external magnetic field, and is characterized by said 2nd ferromagnetic layer being a magnetization fixing layer from which said magnetization direction does not change substantially in the external magnetic field where said magnetization direction of said 3rd ferromagnetic layer changes.

[Claim 18] The magneto-resistive effect head according to claim 10 to 17 characterized by equipping an end with a medium confrontation side, estranging from said medium opposed face, arranging said magneto-resistive effect component, being arranged between said medium opposed faces and said magneto-resistive effect components, and having said magnetic York which leads said large external magnetic field to said magneto-resistive effect component for an external magnetic field in respect of medium confrontation.

[Claim 19] A magnetic-recording medium and the 1st ferromagnetic layer which is the magneto-resistive effect head which reproduces the magnetic information recorded on said magnetic-recording medium, and is equipped with magnetization of the 1st direction, The mixed phase film containing two or more sorts of oxides with which the valences of the same metal differ, Or the insertion layer by which the oxide layer from which the valence of the same metal differs possessed the cascade screen by which the laminating was carried out more than two-layer, and laminating formation was carried out with said 1st ferromagnetic layer, The 2nd ferromagnetic layer which laminating formation is carried out with said 1st ferromagnetic layer through said insertion film, and is equipped with magnetization of said 1st direction and the abbreviation rectangular cross direction, Magnetic-reproducing equipment characterized by carrying a magneto-resistive effect head equipped with a middle non-magnetic layer

and the 3rd ferromagnetic layer to which laminating formation is carried out with said 2nd ferromagnetic layer through said middle non-magnetic layer, and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state.

[Claim 20] The 1st ferromagnetic layer equipped with magnetization of the 1st direction, and the 2nd ferromagnetic layer equipped with magnetization of said 1st direction, and magnetization of the 2nd of the abbreviation rectangular cross direction, The magnetic layered product characterized by providing an interlayer film equipped with the mixed phase film which is an interlayer film formed between said 1st and 2nd ferromagnetic layers, and contained two or more kinds of oxides with which the valences of the same metal differ, or the cascade screen which contains the oxidizing zone from which the valence of the same metal differs more than two-layer.

[Claim 21] The oxide with which said valences differ is a magnetic layered product according to claim 20 characterized by consisting of an oxide of Fe and being chosen out of FeO, Fe 3O4, alpha-Fe 2O3, and gamma-Fe 2O3.

[Claim 22] The oxide with which said valences differ is a magnetic layered product according to claim 20 which consists of an oxide of Cr and is characterized by being chosen out of CrO, Cr 2O3, CrO2 and Cr 2O5, and CrO3 and CrO5.

[Claim 23] The oxide with which said valences differ is a magnetic layered product according to claim 20 which consists of an oxide of Mn and is characterized by being chosen out of MnO and MnO2.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the magneto-resistive effect component which detects change of an external magnetic field, the magneto-resistive effect head possessing this magneto-resistive effect component, the magnetic-reproducing equipment which carries this magneto-resistive effect head, and a magnetic layered product equipped with the two-layer ferromagnetic layer whose still more nearly mutual magnetization direction is an abbreviation rectangular cross.
[0002]
[Description of the Prior Art] Conventionally, read-out of the magnetic information recorded on the magnetic-recording medium made the magnetic head for playback and the record medium which have a coil displaced relatively, and the method of detecting the electrical potential difference in which induction is carried out to a coil by the electromagnetic induction generated in that case was used. Then, the magneto-resistive effect (MagnetoResistance) from which the electric resistance of a specific ferromagnetic changes according to external magnetic field strength was used, and the magneto-resistive effect component (MR component is called.) which reproduces magnetic information was developed (reference, such as IEEE MAG-7,150 (1971)). It is used for a magnetic field sensor, and also this MR component is used as a magneto-resistive effect head (MR head) carried in magnetic-reproducing equipments, such as a hard disk drive.
[0003] Small and large capacity-ization of the magnetic-recording medium which appears in magnetic-reproducing equipment progress increasingly in recent years, the relative velocity of the magnetic head for playback at the time of information read-out and a magnetic-recording medium becomes smaller, and even if it is a small relative velocity, the expectation for the MR head from which high power is obtained is growing.
[0004] The giant magneto-resistance film was developed to such expectation. This giant magneto-resistance film is the multilayers which the laminating of a ferromagnetic metal membrane and the non-magnetic metal film was carried out [multilayers] by turns on predetermined conditions like Fe/Cr or Fe/Cu, and carried out antiferromagnetism association of between the approaching ferromagnetic metal membranes, and the so-called artificial grid film (reference, such as Phys.Rev.Lett.61 2474 (1988) and Phys.Rev.Lett.64 2304 (1990)). However, since the magnetic field required to saturate magnetization of the artificial grid film is large, it is not suitable as a film ingredient for MR heads.
[0005] The example which, on the other hand, realized the big magneto-resistive effect in MR film in which two ferromagnetic metal layers do not carry out magnetic coupling (uncombined) by the multilayers of the ferromagnetic metal layer / non-magnetic metal layer / ferromagnetic metal layer whose non-magnetic metal layer was pinched from the upper and lower sides by the ferromagnetic metal layer is reported. This MR film fixes magnetization (spin) of a ferromagnetic metal layer, and is characterized by carrying out flux reversal of the magnetization of the ferromagnetic layer of another side by the external magnetic field. Since a magneto-resistive effect is acquired by changing by this the relative include angle of the spin direction of the ferromagnetic metal layer arranged on both sides of a non-magnetic layer, such a MR component is called the spin bulb component (reference, such as Phys.Rev.B 45 806 (1992) and J.Appl.Phys.69 4774 (1991)).
[0006] Although such magnetic-reluctance rate of change of a spin bulb component is small compared with the artificial grid film, since its magnetic field required to saturate ** is small, it is suitable for the MR head application, and has already resulted in utilization.
[0007] A general spin bulb component is equipped with the laminated structure of a ferromagnetic free layer, a middle non-magnetic layer, a ferromagnetic pin layer, and an antiferromagnetism layer. Magnetization of the ferromagnetic pin layer which touches an antiferromagnetism layer fixes to an one direction under an external magnetic field by the exchange bias magnetic field from an antiferromagnetism layer. On the other hand, to an external magnetic field, freely, the ferromagnetic free layer is pivotable and can realize easily parallel / anti-parallel condition of magnetization of a ferromagnetic free layer and a ferromagnetic pin layer in a low magnetic field. In

addition, the electric resistance of a component has low magnetization of both the ferromagnetism layer in the parallel condition, electric resistance becomes high in the anti-parallel condition, and the high resistance effectiveness rate of change is obtained by enlarging the difference of two resistance with a spin bulb component.
[0008] In actually using a spin bulb component, in order to obtain high sensitivity using the linearity field of resistance change, as for magnetization of a ferromagnetic free layer, it is desirable to carry out bias so that an abbreviation rectangular cross may be carried out with magnetization of a pin layer all over a zero magnetic field. In case magnetization of a free layer rotates to an external magnetic field, this bias is important also in the semantics of single-domain-izing so that a Barkhausen noise may not occur. For this reason, the hard magnetic film which has the same function as a magnet for the purpose of single-domain-izing is prepared in the side face of the spin bulb film.
[0009] If the thickness of this hard magnetic film can impress suitable bias and becomes thin more than this when equal to a ferromagnetic free layer, single domain-ization of a ferromagnetic free layer cannot attain it easily due to the lack of bias. Moreover, if it becomes thicker than a free layer, it will become the excess of bias and the permeability of a ferromagnetic free layer will fall.
[0010] However, in the present condition, if a hard magnetic film is made thin to thickness equivalent to a ferromagnetic free layer, since both plane-of-composition product becomes small, magnetic junction cannot be performed well, but a thick configuration must be taken for the hard film to a ferromagnetic free layer. Consequently, the bias impressed to a ferromagnetic free layer became superfluous, the permeability of a ferromagnetic free layer fell, and loss is done to sensibility and an output.
[0011] In order to solve this, the laminating of the antiferromagnetism layer of a predetermined configuration is carried out to a free layer edge, magnetization of a free layer edge is fixed by the switched connection of an antiferromagnetism layer and a free layer, and the spin bulb component which took the configuration which impresses bias to the central field response section of a free layer from this part is proposed. Since it is the bias approach using the antiferromagnetism layer processed into the predetermined configuration (pattern), it is called pattern DOBAIASU structure.
[0012] About the spin bulb component of pattern DOBAIASU structure, a perspective view is shown in drawing 20 (a).
[0013] This spin bulb component has the 1st antiferromagnetism layer 1 by which the laminating was carried out to order from the bottom, the ferromagnetic pin layer 3, the middle non-magnetic layer 5, and the ferromagnetic free layer 7, and has the 2nd antiferromagnetism layer 9 of the pair by which the laminating was further carried out to the both ends of the longitudinal direction of the ferromagnetic free layer 7, and the lead electrode 11 of a pair.
[0014] As for the both ends of the ferromagnetic free layer 7, and the ferromagnetic pin layer 3, magnetization of the one direction anisotropy in drawing 20 (a) is given by magnetic switched connection with the 2nd antiferromagnetism layer 9 and the 1st antiferromagnetism layer 1, respectively. That is, magnetization immobilization is carried out rightward in space by both switched connection, and the both ends (slash section) by which the laminating was carried out to the antiferromagnetism layer 9 of [2nd] the ferromagnetic free layers 7 are committed as a hard magnetic film by it. And magnetization of the central field response section inserted at both ends has magnetization of the one direction anisotropy of the direction of an arrow head in a zero magnetic field in response to the bias magnetic field from the both ends of the 2nd antiferromagnetism layer 9 and the ferromagnetic free layer 7. On the other hand, magnetization of the ferromagnetic pin layer 3 fixes by switched connection with the 1st antiferromagnetism layer 1 in the direction which goes to a flesh side from the space table of drawing 20 (a).
[0015] With pattern DOBAIASU structure, the switched connection film of the 2nd antiferromagnetism layer 9 and the ferromagnetic free layer 7 and two switched connection film, the 1st antiferromagnetism layer 1 and the ferromagnetic pin layer 3, are needed. Although heat treatment among a magnetic field performs grant of the one direction anisotropy to the ferromagnetic layer of the switched connection film, each must heat-treat, where a magnetic field which is different in each of both the antiferromagnetism layers 1 and 9 is impressed from the need of carrying out magnetization of the ferromagnetic pin layer 3 which does effect, and the ferromagnetic free layer 7 to direct relation. The heat treatment stroke (time amount-temperature) at the time of setting to TB2 blocking temperature of the 2nd antiferromagnetism layer 9 from which a switched connection magnetic field with TB1 and a ferromagnetic free layer becomes zero about the blocking temperature of the 1st antiferromagnetism layer 1 from which a switched connection magnetic field with the ferromagnetic pin layer 3 becomes zero is shown in drawing 20 (b). In addition, the bidirectional arrow head shows the magnetization condition for convenience from the antiferromagnetism film having uniaxial anisotropy.
[0016] In order to perform completely magnetization fixing by the 1st and 2nd antiferromagnetism layers 1 and 9, two kinds of antiferromagnetism layer ingredients with large difference |Tb1-Tb2| of blocking temperature are needed, and two sorts of antiferromagnetism layer ingredients with small distribution of a switched connection magnetic field are needed for extent with which both switched connection magnetic field does not lap further.

Furthermore, in addition to these conditions, in case it uses for a spin bulb component, the ingredient it essentially has an ingredient and the property of an important high switched connection magnetic field and high blocking temperature cannot be discovered easily.
[0017] On the other hand, in 3 layer structures, such as CoFe/Mn/CoFe by epitaxial growth, magnetic rectangular cross association between two ferromagnetic layers CoFe is observed (reference, such as J.Appl.Phys.79 (8) and 15April 1996).
[0018]
[Problem(s) to be Solved by the Invention] This invention aims at offering the new magneto-resistive effect component devised under such the actual condition, and offering the low magneto-resistive effect component, the magneto-resistive effect head, the magnetic-reproducing equipment, and the magnetic layered product of a manufacturing cost especially.
[0019]
[Means for Solving the Problem] The 1st ferromagnetic layer equipped with magnetization of the 1st direction the first of this invention to the above-mentioned technical problem, The magnetization binder course by which laminating formation was carried out with the 1st ferromagnetic layer, and the 2nd ferromagnetic layer in which laminating formation is carried out with the 1st ferromagnetic layer through a magnetization binder course, and magnetization association is carried out by the magnetization binder course with the 1st ferromagnetic layer and which is equipped with magnetization of the 1st direction and the abbreviation rectangular cross direction, The magneto-resistive effect component characterized by having a middle non-magnetic layer and the 3rd ferromagnetic layer to which laminating formation is carried out with the 2nd ferromagnetic layer through a middle non-magnetic layer, and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state is offered.
[0020] Moreover, the mixed phase film containing two or more sorts of oxides with which the valences of the metal as the 1st ferromagnetic layer equipped with magnetization of the 1st direction with the second [same] of this invention differ, Or the insertion layer by which the oxide layer from which the valence of the same metal differs possessed the cascade screen by which the laminating was carried out more than two-layer, and laminating formation was carried out with the 1st ferromagnetic layer, The 2nd ferromagnetic layer which laminating formation is carried out with the 1st ferromagnetic layer through an insertion layer, and is equipped with magnetization of the 1st direction and the abbreviation rectangular cross direction, The magneto-resistive effect component characterized by having a middle non-magnetic layer and the 3rd ferromagnetic layer to which laminating formation is carried out with the 2nd ferromagnetic layer through a middle non-magnetic layer, and which an external magnetic field equips with magnetization of the 1st direction and an almost same direction by the zero state is offered.
[0021] These magneto-resistive effect components have magnetization of abbreviation orthogonality relation at a zero state mutually [the 2nd ferromagnetic layer and the 3rd ferromagnetic layer which pinch the middle non-magnetic layer of an external magnetic field by the zero state / an external magnetic field]. And the magnetization direction of the 1st ferromagnetic layer and the 2nd ferromagnetic layer is combined in the abbreviation rectangular cross direction by a magnetization binder course or the insertion layer. Therefore, it becomes possible to become possible to make the magnetization direction of the 1st and 3rd ferromagnetic layers in the abbreviation same direction, therefore to reduce the heat treatment process for magnetic-bias grant, as a result to attain simplification of a production process.
[0022] In addition, simplification of such a process is contributing-to productivity drive of the magnetic head size, and offer of magnetic-reproducing equipment of it is attained at a magneto-resistive effect head with a low unit price, and a pan.
[0023] The thing of an antiferromagnetism layer besides the switched connection bias which used the 1st and 2nd antiferromagnetism layers for the magnetic bias to the 1st and 3rd ferromagnetic layers at each for which the cascade screen of a hard magnetic layer and two or more ferromagnetic layers, the cascade screen of a ferromagnetic layer and a nonmagnetic phase, the cascade screen of an antiferromagnetism layer and a ferromagnetic layer, and the cascade screen of a hard magnetic layer and a ferromagnetic layer are used for replacing is also possible.
[0024] And a degree of freedom is obtained by selection of these homogeneous ingredients in grant of magnetic bias. For example, when using an antiferromagnetism layer for magnetic-bias grant, it becomes unnecessary to prepare a difference in the blocking temperature of two antiferromagnetism layers, and can be suitably chosen as it from well-known ingredient, for example, IrMn, PtMn, FeMn, NiMn, NiO, and alpha-Fe 2O3 grade.
[0025] In the magneto-resistive effect component, the magneto-resistive effect head, and magnetic-reproducing equipment of this invention, it is desirable to have the next configuration.
[0026] 1) The 2nd ferromagnetic layer is a magnetization free layer which changes the magnetization direction with fluctuation of an external magnetic field, and said 3rd ferromagnetic layer is a magnetization pin layer which does

not change the magnetization direction substantially in the external magnetic field which changes magnetization of said magnetization free layer. Under the present circumstances, magnetization of the 1st ferromagnetic layer is good also as a configuration which is not rotated as a configuration collectively rotated to the magnetization direction change of the 2nd ferromagnetic layer. **** 2 and the 3rd ferromagnetic layer can be mutually made uncombined magnetically.

[0027] 2) The 3rd ferromagnetic layer is a magnetization free layer which changes the magnetization direction with fluctuation of an external magnetic field, and the 2nd ferromagnetic layer is a magnetization pin layer which does not change the magnetization direction substantially in the external magnetic field which changes magnetization of a magnetization free layer. Under the present circumstances, as for magnetization of the 1st ferromagnetic layer, in the external magnetic field which changes magnetization of a magnetization free layer, not changing substantially is desirable. In addition, the 2nd and 3rd ferromagnetic layers can be mutually made uncombined magnetically.

[0028] 3) Laminating formation of the 1st antiferromagnetism layer is carried out only to the both ends in the longitudinal direction of the 1st ferromagnetic layer. Or/and, the 2nd antiferromagnetism layer is formed only in the both ends in the longitudinal direction of said 3rd ferromagnetic layer.

[0029] 4) The 1st antiferromagnetism layer is formed so that the whole 1 surface surface of said 1st ferromagnetic layer may be covered.

[0030] 5) It has a non-magnetic layer further between the 1st antiferromagnetism layer and the 1st ferromagnetic layer or between the 2nd antiferromagnetism layer and the 3rd ferromagnetic layer.

[0031] 6) The 1st, 2nd, and 3rd ferromagnetic layers are equipped with the interlayer for antiferromagnetism association who does magnetization association of two ferromagnetic layers and these in antiferromagnetism. Two ferromagnetic layers which carried out antiferromagnetism-association, and middle class constitute the unit called so-called synthetic antiferromagnetism film, since two ferromagnetic layers turn to anti-parallel mutually, a field can close them within a unit and they can reduce the leakage magnetic field to the exterior, and they can control the bias point suitably.

[0032] 7) A magnetization binder course or an insertion layer possesses the mixed phase film containing two or more sorts of oxides with which the valences of the same metal differ, or the cascade screen to which the laminating of the oxide layer from which the valence of the same metal differs was carried out more than two-layer. Here, the oxide with which the valences of the same metal differ is chosen from 7-2CrO chosen from 7-1FeO, Fe3O4, alpha-Fe 2O3, and gamma-Fe 2O3, Cr2O3, CrO2 and Cr 2O5, and CrO3 and CrO5.

[0033] 7-3) It is chosen out of MnO and MnO2.

[0034] 8) A magnetization binder course or insertion layers are insulating layers, such as an oxide, by having further the new insulating layer whose middle non-magnetic layer is pinched with this magnetization binder course, carry out induction of the electronic specular reflection by the interface of each insulating layer, and it is constituted and the reflected electron becomes so that it may come to an interface with a middle non-magnetic layer again. This electronic reflecting layer is known as speculer effectiveness.

[0035] 9) The 1st and 2nd ferromagnetic layers which carried out rectangular association mutually by the magnetization binder course or the insertion layer will cause two kinds of magnetization rotations as follows by selection of an ingredient etc., if an external magnetic field is impressed.

[0036] 9-1) Rectangular association goes out, it is maintained and only the 2nd ferromagnetic layer carries out magnetization rotation of the switched connection of the 1st ferromagnetic layer and the 1st antiferromagnetism layer.

[0037] 9-2) Rectangular association is maintained and magnetization of the 1st and 2nd ferromagnetic layers rotates to an external magnetic field because association with the 1st ferromagnetic layer and the 1st antiferromagnetism layer goes out.

[0038] In addition, the magneto-resistive effect head of this invention is the so-called shielding mold head by which 10 magneto-resistive-effect component is arranged in the magnetic gap near the medium opposed face of the magnetic head. Although distribution of the switched connection magnetic field of the switched connection film increases by making an antiferromagnetism layer thin, since it becomes unnecessary to avoid duplication of distribution according to this invention, thin film-ization of an antiferromagnetism layer is also easily realizable. Thin film-ization of such an antiferromagnetism layer is suitable for narrow gap-ization of a shielding mold magneto-resistive effect head, and has the effectiveness which can contribute to the densification.

[0039] 11) It is the York mold magneto-resistive effect head equipped with magnetic York which a magneto-resistive effect component estranges, is arranged from a medium confrontation side, is extended from a medium opposed face to a magneto-resistive effect component, and transmits the signal field from a medium to a magneto-resistive effect component. Since the count of heat treatment of bias grant can be reduced for the magneto-resistive effect component of this invention, a uniform magnetic anisotropy becomes is hard to be given to the York section, and the efficient magnetic-flux installation to a magneto-resistive effect component from a medium opposed face can be expected.

[0040] Moreover, the 1st ferromagnetic layer which the third of this invention equips with magnetization of the 1st direction, The 2nd ferromagnetic layer equipped with magnetization of the 1st direction, and magnetization of the 2nd of the abbreviation rectangular cross direction, It is the interlayer film formed between the 1st and 2nd ferromagnetic layers, and the magnetic layered product possessing an interlayer film equipped with the mixed phase film containing two or more kinds of oxides with which the valences of the same metal differ, or the cascade screen which contains the oxidizing zone from which the valence of the same metal differs more than two-layer is offered.

[0041]

[Embodiment of the Invention] (Gestalt of the 1st operation) The 1st operation gestalt concerning the magneto-resistive effect component of this invention is explained using drawing 1 .

[0042] Drawing 1 is the perspective view showing a magneto-resistive effect component. The field of this side in drawing 1 hits the penetration side of the external magnetic field which a magneto-resistive effect component detects. It follows, for example, when this magneto-resistive effect component is carried in the shielding mold magnetic head which reads the magnetic-recording information on the front face of a magnetic-recording medium, opposite arrangement of the external magnetic field penetration side is carried out on the front face of a magnetic-recording medium.

[0043] The magneto-resistive effect component of this 1st operation gestalt By the 1st antiferromagnetism layer 31, the 1st ferromagnetic layer 33 which laminating formation was carried out and carried out switched connection to this 1st antiferromagnetism layer 31 with this 1st antiferromagnetism layer 31, the magnetization binder course (insertion layer) 35 which combines magnetization of two adjoining ferromagnetic layers in the abbreviation rectangular cross direction, and this binder course 35 The laminating of the 1st ferromagnetic layer 33, the 2nd ferromagnetic layer 37 equipped with magnetization of the rectangular direction, the middle non-magnetic layer 39, and the 3rd ferromagnetic layer 41 is carried out one by one. And it has the 2nd antiferromagnetism layer 43 of the pair formed on the both ends in the longitudinal direction of the 3rd ferromagnetic layer 41, and the lead electrode 45 of a pair. In addition, this magneto-resistive effect component is formed on the ceramic substrate which is not too illustrated through a magnetic gap, magnetic shielding, etc. which are not illustrated.

[0044] The 1st ferromagnetic layer 33 is equipped with the magnetization which fixed substantially in the direction of an arrow head of drawing 1 (right in space) by switched connection with the 1st antiferromagnetism layer 31. Magnetization of the 1st and 2nd ferromagnetic layers 33 and 37 is mutually combined in the abbreviation rectangular cross direction by the binder course 35 for rectangular magnetization, and, therefore, magnetization fixes magnetization of the 2nd ferromagnetic layer 37 in the direction which goes to a flesh side from the table of abbreviation space. Thus, the 2nd ferromagnetic layer 37 by which magnetization fixing was carried out is equivalent to the so-called ferromagnetic pin layer to which the magnetization does not move substantially in external magnetic fields, such as a signal field.

[0045] The 3rd ferromagnetic layer 41 which adjoined each other through this ferromagnetic pin layer 37 and the middle non-magnetic layer 39 is free to extent which can rotate the magnetization direction of that central field response section in response to an external magnetic field in a ferromagnetic free layer. In order to impress magnetic bias to this ferromagnetic free layer 41, the 2nd antiferromagnetism layer 43 is arranged on the both ends (slash hatching section) of the truck cross direction of the ferromagnetic free layer 41, the both ends of the ferromagnetic free layer 41 carry out switched connection to the 2nd antiferromagnetism layer 43, and magnetization fixing is carried out in the direction of an arrow head of drawing (space right). Therefore, the center section of the ferromagnetic free layer 41 will receive rightward bias magnetization in space, and will be equipped with magnetization in the direction shown in the arrow head of drawing 1 in a zero magnetic field. Such is carried out and, as for the ferromagnetic pin layer 37 and the ferromagnetic free layer 41 through the middle non-magnetic layer 39, magnetization can realize the so-called spin bulb component of orthogonality relation.

[0046] In addition, with the configuration of drawing 1 , a space longitudinal direction corresponds crosswise [of a magneto-resistive effect component / truck], and regenerative-track width of face carries out abbreviation coincidence at the width of face of the central field response section of a ferromagnetic free layer.

[0047] Now, in this spin bulb component, switched connection of the 1st ferromagnetic layer 33 and the ferromagnetic free layer 41 can be considered as magnetization of the same direction. This can be attained by having added the binder course 35 for rectangular association and the 1st ferromagnetic layer 33 which are not in the conventional spin bulb component.

[0048] As shown in the heat treatment time amount and heat-treatment-temperature relation of drawing 2 , the processing in the magnetic field (right in the space of drawing 2) of an one direction can perform the heat treatment process in a magnetic field in the production process of this spin bulb component in the condition of having made it the elevated temperature from blocking temperature (for example, TB1, TB2). As compared with heat treatment of two conventional processes among a magnetic field, this is simple, as a result contributes to the productivity drive of a spin bulb component. In addition, AF shows an antiferromagnetism layer among drawing 2 ,

and since an antiferromagnetism layer is equipped with uniaxial anisotropy, it shows the uniaxial anisotropy by the bidirectional arrow head. Moreover, the heat treatment process described above is performed after forming each class by a spatter etc.

[0049] The 1st operation gestalt explained above is **** to the component structure which is the bottom type spin bulb component by which the ferromagnetic pin layer 37 is formed in a substrate side rather than the ferromagnetic free layer 41, and has a binder course 35 in the ferromagnetic pin layer 37 side.

[0050] Next, sequential explanation of the modification 1-1 concerning this 1st operation gestalt thru/or 1-4 is given. In addition, in a modification 1-1 thru/or 1-4, it supposes that the sign given in the 1st operation gestalt about the same configuration as the configuration in the 1st operation gestalt is used, and the detailed explanation is omitted.

[0051] (Modification 1-1) Drawing 3 is drawing which observed the cross section of a **** spin bulb component from the medium opposed face in the modification 1-1.

[0052] It is that this modification 1-1 differs from the gestalt of the 1st operation in the point that the inside edge of the lead electrode 45 has been arranged inside the side face of the 2nd antiferromagnetism layer 43 which counters mutually, and has covered the part on the ferromagnetic free layer 41. Among drawing 3 , since magnetization has fixed the part shown with a slash among the ferromagnetic free layers 41 by switched connection with the 2nd antiferromagnetism layer 43, it is the neutral zone which does not react to a signal field, and the central field inserted into this neutral zone is the central field response section. Therefore, since the lead electrode is in contact with the central response section, the neutral zone which is not contributed to a magneto-resistive effect can be bypassed electrically, and improvement in sensibility can be aimed at.

[0053] In addition, the sign 47 after drawing 3 shows the substrate layer formed in the front face of a magnetic gap or a magnetic gap. The ingredient of this substrate layer 47, crystallinity, etc. can be suitably chosen so that a class, a crystal stacking tendency, etc. of the crystal in each class formed on this may be made suitable.

[0054] (Modification 1-2) Next, drawing 4 shows drawing which observed the **** cross section from the medium opposed face for the spin bulb component of a modification 1-2.

[0055] This modification 1-2 differs from the gestalt of the 1st operation in the point that the laminating of antiferromagnetism layer 43' is carried out to all the upper front faces of the ferromagnetic free layer 41.

[0056] Thus, when the whole surface laminating of antiferromagnetism layer 43' and the ferromagnetic free layer 41 is carried out, an external magnetic field is [magnetization of the ferromagnetic free layer 41] the right in space of drawing 4 in a zero state, and when an external magnetic field is given, it is necessary to make the switched connection force into extent which can be freely rotated in response to this.

[0057] However, in the switched connection by the whole surface laminating, association tends to become strong and there is a possibility that the permeability of the ferromagnetic free layer 41 may fall and sensibility may fall.

[0058] (Modification 1-3) In order to prevent this sensibility fall, as shown in the sectional view (observation Fig. from a medium opposed face side) of drawing 5 , in the modification 1-3, it can adjust by inserting a non-magnetic layer 49 between 2nd antiferromagnetism layer 43' and the ferromagnetic free layer 41 so that it may become weak to the value of a request of the switched connection force.

[0059] About this modification 1-2 and 1-3, it is employable similarly in the 2nd [which is explained later] thru/or 4th operation gestalt.

[0060] Furthermore, the non-magnetic layer 49 which adjusts the magnetic coupling of a modification 1-3 All the top faces of a ferromagnetic layer where antiferromagnetism layer 43' like a modification 1-2 adjoins through a non-magnetic layer 49 not only in a wrap configuration Also when an antiferromagnetism layer forms on the subregion of the ferromagnetic layer in the 1st operation gestalt or 2nd [which is explained later] thru/or 4th operation gestalt, it can insert similarly and can use.

[0061] (Modification 1-4) Drawing 6 (a) is drawing which observed the cross section of a **** spin bulb component from the medium opposed face side in the modification 1-4.

[0062] When the switched connection energy which fixes magnetization of the ferromagnetic pin layer 37 is set constant, it is hard coming to carry out flux reversal with the spin bulb component of the 1st operation gestalt, so that magnetization of the ferromagnetic pin layer 37 is made small. Then, it is making a ferromagnetic pin layer into laminating ferry structure and the laminated structure which consists of the 1st ferromagnetism pin layer 55, a 2nd ferromagnetism pin layer 51, and an interlayer 53 that does magnetic coupling of these in antiferromagnetism as specifically shown in drawing 6 (a), and it is possible to control the flux reversal of the ferromagnetic pin layer 37. Moreover, with the structure of drawing 6 (a), the magnetic field where rectangular association is held can be made high by introducing laminating ferry structure. Therefore, the magnetic field which the flux reversal of magnetic layers 33, 51, and 55 produces can be made very high.

[0063] Moreover, as other examples which introduced laminating ferry structure, as shown in drawing 6 (b), the interlayer 53 who does magnetic coupling of the ferromagnetic layers 57 and 33 of laminating ferry structure and the ferromagnetic layer of these in antiferromagnetism can be introduced between the 1st antiferromagnetism layer

31 and the magnetization binder course 35 for rectangular association (insertion layer). In this case, the switched connection magnetic field of the 1st antiferromagnetism layer 31 and laminating ferry structure can be made high. In addition, Ru, Cu, etc. are suitable for the interlayer 53 in laminating ferry structure.
[0064] (Gestalt of the 2nd operation) Next, the 2nd operation gestalt concerning the magneto-resistive effect component of this invention is explained using drawing 7 .
[0065] Drawing 7 shows drawing which observed the cross section of a **** spin bulb component from the penetration side of an external magnetic field in the 2nd operation gestalt.
[0066] As the 2nd spin bulb component is shown in drawing 7 , on the front face of the substrate layer 47 It comes to carry out the laminating of the 1st antiferromagnetism layer 61, the ferromagnetic pin layer 63, the middle non-magnetic layer 65, the ferromagnetic free layer 67, the magnetization binder course 69 for rectangular association, and the ferromagnetic layer 71 to this order. The 2nd antiferromagnetism layer 73 is formed on the top-face both ends of the ferromagnetic layer 71, and the lead electrode 75 is electrically connected to these film.
[0067] This spin bulb component is the bottom type with which the ferromagnetic pin layer 63 was formed in the substrate layer side rather than the ferromagnetic layer 67, and equips the ferromagnetic free layer 67 side with the magnetization binder course 69 for rectangular association (insertion layer). The lead electrode 75 is equivalent to what was explained in the 1st operation gestalt.
[0068] By switched connection with the 2nd antiferromagnetism layer 73, the slash section of the both ends of the ferromagnetic layer 71 is the field which fixed from the drawing 7 space table by magnetization of the direction of the other side to the flesh side, and gives the magnetic bias of the magnetization direction concerned to a central active region. Magnetization of the central field of the ferromagnetic layer 71 is set up in the direction in which an external magnetic field goes to a flesh side from the space table of drawing 7 in zero by this.
[0069] And by the interlayer for rectangular association, the ferromagnetic layer 71 and the ferromagnetic free layer 67 to which magnetization association of the rectangular direction was given will be equipped with magnetization of the space right as shown in drawing 7 , and an external magnetic field can realize rectangular magnetization of the ferromagnetic pin layer 63 and the ferromagnetic free layer 67 in zero.
[0070] (Modification 2-1) Magnetization can make magnetization of the ferromagnetic pin layer 63 and the ferromagnetic free layer 67 intersect an abbreviation rectangular cross in this way using two antiferromagnetism layers 61 and 73 of the same shaft.
[0071] drawing 8 -- this -- the -- two -- operation -- a gestalt -- a modification -- it is -- the -- two -- antiferromagnetism -- a layer -- 73 -- ' -- touching -- ferromagnetism -- a layer -- 71 -- ' -- and -- a rectangular cross -- association -- ** -- an interlayer -- 69 -- ' -- two -- a ** -- it is -- the -- two -- antiferromagnetism -- a layer -- 73 -- ' -- respectively -- ** -- it is drawing which observed the cross-section structure which carried out patterning so that location adjustment might be carried out from the inflow side of an external magnetic field. If it does in this way, the shunt effect of a current can be reduced and it will become possible to increase substantially contribution of the magnetic-reluctance rate of change by flux reversal.
[0072] (Gestalt of the 3rd operation) Next, the 3rd operation gestalt concerning the magneto-resistive effect component of this invention is explained using drawing 9 (a).
[0073] Drawing 9 (a) is drawing which observed the cross section of a **** spin bulb component from the penetration side of an external magnetic field in the 3rd operation gestalt.
[0074] As a **** spin bulb component is shown in the 3rd operation gestalt at drawing 9 (a) On the substrate layer 47, by the 1st antiferromagnetism layer 81, the ferromagnetic free layer 83, the middle non-magnetic layer 85, the ferromagnetic pin layer 87, the magnetization binder course 89 for rectangular association, and the binder course 89 It has the structure where the laminating of the ferromagnetic layer 91 which carries out magnetic coupling to the ferromagnetic pin layer 87 at an abbreviation rectangular cross, the 2nd antiferromagnetism layer 93 which carries out switched connection to this ferromagnetic layer 91, and the lead electrode 95 was carried out one by one.
[0075] In addition, switched connection of the 1st antiferromagnetism layer 81 is carried out to the both ends (slash hatching section in drawing 9 (a)) of the ferromagnetic free layer 83, consequently a bias field is given from the edge of the ferromagnetic free layer 83 to the central magnetosensitive field of the ferromagnetic free layer 83, a signal field is a zero state and a magnetosensitive field is equipped with the magnetization shown by the arrow head of drawing 9 (a).
[0076] With this component, magnetization fixing of the ferromagnetic pin layer 87 and the heat treatment routing counter of two antiferromagnetism layers 81 and 93 to the ferromagnetic free layer 83 used for bias grant can be reduced the same with having explained in the 1st operation gestalt compared with the former.
[0077] Now, it is not necessary to be the ferromagnetic free layer 83 between the two 1st antiferromagnetism layer 81 estranged and arranged, and with the 3rd operation gestalt, as shown in the sectional view observed from the medium opposed face side of drawing 9 (b), it may use the spacing layer 97. This spacing layer 97 has desirable insulating materials used for magnetic devices, such as the magnetic head, such as AlOx and SiOx, in order to reduce a shunt effect. Moreover, Cu, Ru, NiFe, NiFeCr, etc. can be used from the meaning which raises the crystal

stacking tendency of the ferromagnetic free layer 83. Furthermore, it is good also as carrying out the laminating of the ingredient layer different [among these], or an interstratification object.
[0078] (Gestalt of the 4th operation) Drawing 10 is drawing which observed the cross section of the spin bulb component concerning the 4th operation gestalt of this invention from the signal inflow side.
[0079] As the spin bulb component of the 4th operation gestalt is shown in drawing 1010 , on the substrate layer 47 So that magnetization of the ferromagnetic layer 103 which extends between the 1st antiferromagnetism layer 101 of the 1st two antiferromagnetism layer [101 or 2] which estranged mutually and was formed, and on it, the ferromagnetic layer 103, and the ferromagnetic free layer 107 may become an abbreviation rectangular cross It has the magnetization binder course 105 to which magnetic coupling of both the layers is carried out, the ferromagnetic free layer 107, the middle non-magnetic layer 109, the ferromagnetic pin layer 111, the 2nd antiferromagnetism layer 113, and the lead electrode 115.
[0080] Moreover, drawing 11 is drawing which observed the cross section of the spin bulb component which has arranged the spacing layer 117 similarly with having explained in the gestalt of the 3rd operation between the 1st antiferromagnetism layer 101 estranged mutually from the inflow side side of an external magnetic field in the 4th operation gestalt. An ingredient which the 3rd operation gestalt sets and was explained as this spacing layer 117 is employable.
[0081] In drawing 10 and drawing 11 , magnetization fixes the both ends (drawing 10 and slash hatching section of drawing 11) by which the laminating was carried out on the 1st antiferromagnetism layer 101 among the ferromagnetic layers 103 by switched connection with the 1st antiferromagnetism layer 101, and the central magnetosensitive field inserted into these both ends is equipped with the magnetization to the direction of a flesh side from a space table by the magnetic bias from these both ends.
[0082] Moreover, the ferromagnetic pin layer 111 is equipped with magnetization of the flesh-side sense from a space table by switched connection with the antiferromagnetism layer 113, therefore a heat treatment routing counter required for grant of fixing magnetization and grant of the magnetic bias to the ferromagnetic layer 103 to the ferromagnetic pin layer 111 can be reduced also in this operation gestalt, and the same effectiveness is acquired with other operation gestalten having explained.
[0083] In the above, the drawing was used and explained to the 1st thru/or the gestalt and its example of modification of the 4th operation about the **** magneto-resistive effect component.
[0084] Next, the ingredient used for the magnetization binder course for rectangular association in this invention (interlayer) and rectangular association are explained.
[0085] The mixed phase film containing two or more sorts of oxides with which the valences of the same metal differ, or the cascade screen to which the laminating of the oxide layer from which the valence of the same metal differs was carried out more than two-layer can be used for a magnetization binder course (interlayer). Here, as an oxide with which valences differ, it consists of an oxide of 1Fe and is chosen out of FeO, Fe 3O4, alpha-Fe 2O3, and gamma-Fe 2O3.
2) It consists of an oxide of Cr and is chosen out of CrO, Cr 2O3, CrO2 and Cr 2O5, and CrO3 and CrO5.
3) The oxide with which valences differ consists of an oxide of Mn, and is chosen from MnO and MnO2.
[0086] Moreover, it is realizable for a magnetization binder course by the cascade screen of Au, aluminum, Ag, Cu, Cr or Mn, these mixolimnions or these single element layer, and a mixolimnion.
[0087] When the unit vectors of magnetization to which the laminating of the two ferromagnetic layers was carried out through the interlayer for rectangular association and which the ferromagnetic layer of two sheets of a ferromagnetic layer / the interlayer / ferromagnetic layer for rectangular association has are M1 and M2,

$$E_c = -A_{12} M_1 \cdot M_2 - B_{12} (M_1 \cdot M_2)^2 \quad (1)$$

respectively, it is the binding energy Ec between ferromagnetic layers,

It is come out and expressed. Here, a congruence primary switched connection constant usual in A12 and B12 are congruence secondary switched connection constants. 90 abbreviation (rectangular cross) association takes place at |A12|<|B12| and the time of B12<0.
[0088] When the ferromagnetic integrated state which is A12 <antiferromagnetism integrated state [which is 0] and A12> 0 is intermingled, induction of B12 is carried out. since [from which an interlayer's thickness increases A12 on the other hand] it is alike and follows and vibrates -- an actual sample -- irregularity -- **** -- if it is -- thickness distribution -- it can do -- as a result -- A -- 12< 0 andA12>0 will be intermingled, and 90 abbreviation association will take place. When the difference of the congruence linear combination energy the surface irregularity for one atom exists in an interlayer by periodic 2L, and according to the irregularity is 2deltaJ, the congruence secondary bond constant B12 is. B12=-[2(deltaJ) 2L/(Api3)] sigmam=1 infinity[coth[pi (2m-1) (D1 /L)

] / (2m-1) 3+coth [pi(2m-1) (D2/L)]/(2m- 1) 3] It is expressed (2) (Phys.Rev.B 67 and 3172 (1991)).

[0089] Here, D1 and D2 show the thickness of two ferromagnetic layers, respectively, and A is the exchange stiffness constant of a ferromagnetic proper. B12 is greatly dependent on membranous smooth nature and thickness so that it may understand from now on. Therefore, it is expected that dispersion appears in B12 by the setups of sample creation. With epitaxial growth, three layer membranes which consist of various ferromagnetic layer / the interlayers / ferromagnetic layers for rectangular association are created, and the orientation side and B12 obtained are shown in Table 1.
[0090]
[Table 1]

中間層	膜構成	配向面	B_{12} [erg/cm^2]
Au	Fe/Au (8ML) /Fe	(001)	-0.003
Al	Fe (4.6ML) /Al (1.6ML) /Fe (4.6ML)	(001)	-0.036
Ag	Fe (9ML) /Ag (6ML) /Fe (16 ML)	(001)	-0.070
Cu	Co (4ML) /Cu (10ML) /Co (10ML)	(001)	-0.015
Cu	Fe (9.4ML) /Cu (9ML) /Fe (16ML)	(001)	-0.10
Cr	Fe/Cr (4ML) /Fe	(001)	-0.2
Mn	CoFe (10nm) /Mn (1.12nm) /CoFe (10nm)	(001)	-3.0

[0091] ML is the unit of an atomic layer among Table 1, and 1ML shows one atomic layer.
[0092] In addition, the thickness of the interlayer for rectangular association has about 0.2 to desirable 2nm which is the range which association realizes 90 degrees.
[0093] Moreover, in addition to the ingredient described previously, a metallic oxide, a metal nitride, and a metal fluoride can be considered as an interlayer for rectangular association of this invention. If it is the ingredient which contains in these the metal from which magnetism differs with a valence, the mixed phase condition of a ferromagnetic phase, an antiferromagnetism phase, and a ferrimagnetism phase is realizable by controlling advance of oxidation, nitriding, and fluoride.
[0094] For example, Fe oxides (FeO, Fe 3O4, alpha-Fe 2O3, gamma-Fe 2O3), these mixed phase film, or a cascade screen is mentioned. About 10nm of thickness of these interlayers for rectangular association is preferably set to about 0.5 to about 3nm from about 0.2nm. By the example 1 about the spin bulb film which used Fe oxide for the middle class for rectangular association thru/or measurement of 4, while checking combining magnetization of the ferromagnetic layer which Fe oxide adjoins, it is the following, and the binding energy was made and measured.
[0095] An example 1 thru/or 4 carried out sequential membrane formation on thermal oxidation Si using the DC magnetron sputtering method. Then, impressing the magnetic field of 7kOe(s) in a vacuum, thermal oxidation Si was warmed at 270 degrees C, and heat treatment of 1 hour was performed. Thereby, magnetization of CoFe fixes by switched connection energy Jua=Hua-Ms-t**0.14 erg/cm2 of the IrMn/CoFe interface of each example. Hua is [the saturation magnetization (1.8T) of a pin layer and t of a switched connection magnetic field (here 500 Oe(s)) and Ms] the thickness (2nm) of a pin layer here. The lamination of each example is shown in Table 2. Each example is formed on a thermal oxidation Si substrate by the approach as stated above sequentially from the left of Table 2.
[0096]
[Table 2]

Fe 酸化物を第 1 の直交結合用中間層としたときのスピンバルブ

実施例 1	Ta (5nm) /NiFe (2nm) /IrMn (7nm) /CoFe （A） (2nm) /Fe (2nm) / 自然酸化 (12000 Langmuirs) / CoFe （B） (2nm) /Cu (2nm) /CoFe （C） (2nm) /Cu (1nm) /Ta (0. 4nm)
実施例 2	Ta (5nm) /NiFe (2nm) /IrMn (7nm) /CoFe (2nm) /Fe (2nm) / 自然酸化 (600～12000 Langmuirs) /CoFe (2nm) /Cu (2nm) / CoFe (2nm) /Cu (1nm) /Ta (0. 4nm)
実施例 3	Ta (5nm) /NiFe (2nm) /IrMn (7nm) /CoFe (1 あるいは 2nm) /Fe (1 あるいは 2nm) / 自然酸化 (3000 Langmuirs) /CoFe (2nm) /Cu (2nm) / CoFe (2nm) /Cu (1nm) /Ta (0. 4nm)
実施例 4	Ta (5nm) /NiFe (2nm) /IrMn (7nm) /CoFe (2nm) /Fe (1～4nm) / 自然酸化 (3000 あるいは 12000 Langmuirs) /CoFe (2nm) /Cu (2nm) / CoFe (2nm) /Cu (1nm) /Ta (0. 4nm)

Cr 酸化物を直交結合用中間層としたときのスピンバルブ

実施例 5	Ta (5nm) /Ru (2nm) /PtMn (10nm) /CoFe (2nm) /Ru (1nm) /CoFe (1nm) /Cr (0 ～ 0. 7nm) / 自然酸化 (300 Langmuirs) /CoFe (2nm) /Cu (2nm) /CoFe (2nm) /Cu (1nm) / 自然酸化 (300 Langmuirs) /Ta (0. 4nm)

(注 1) 実施例 1 乃至 5 の NiFe の化学量論的組成は Ni80%Fe20%、CoFe の化学量論的組成は Co90%Fe10%、IrMn の化学量論的組成は Ir22%Mn78%である。

(注 2) 実施例 1 乃至 4 の上表面は、Cu-Ta 酸化物になっている。

[0097] Here, langmuire is a unit about oxidizing intensity and the amount in which it is exposed to an oxygen tension 1x10-6Torr ambient atmosphere for 1 second, and an oxide is formed is shown.

[0098] The magnetization curve and MR curve of an example 1 which used Fe oxide for the interlayer for rectangular association are shown in drawing 12 (a), (c), drawing 12 (b), and (d), respectively. The magnetization curves and MR curves at the time of introducing an external magnetic field (Hex) in parallel to the direction (Hua) of an exchange bias magnetic field from an IrMn antiferromagnetism layer are drawing 12 (a) and (c), and the magnetization curves and MR curves at the time of introducing perpendicularly are drawing 12 (b) and (d). If Hua and Hex were parallel, a little less than 8% of MR rate of change was shown, and if Hua and Hex were perpendicular, a little more than 10% of MR rate of change was shown. When the condition that magnetization of the CoFe ferromagnetism free layer whose Cu middle non-magnetic layer was pinched, and a CoFe ferromagnetism pin layer serves as perfect anti-parallel is realized and MR considers that maximum is shown, at the time of parallel ****, it turns out that magnetization of a free layer and a pin layer did not become perfect anti-parallel, but anti-parallel are realized when it is perpendicular ****. That is, it can be said that magnetization of the CoFe ferromagnetism pin layer which exists on both sides of the interlayer for rectangular association who consists of the CoFe ferromagnetism layer which has fixed magnetization, this ferromagnetic layer, and a Fe oxide by the exchange bias magnetic field from IrMn has the relation of an abbreviation rectangular cross.

[0099] Now, in the example 1, when an external magnetic field was impressed, the magnetic field whose magnetization of a CoFe ferromagnetism pin layer and a CoFe free layer stops being anti-parallel was 380Oe extent. This means that the magnetic coupling energy by Fe oxide is two or more [0.11erg //cm].

[0100] In the example 2, the oxidizing intensity in the natural oxidation of the interlayer for rectangular association was changed.

[0101] The oxidizing intensity dependency of magnetic field H90 degree to which the anti-parallel condition when carrying out perpendicular **** of the magnetic field is beaten by drawing 13 , and electric resistance rate of change is shown. Fe oxide required for making it join together 90 degrees in 600Langmuiers(es) is not made, but it is 1200Langmuiers. Association is realized 90 degrees above.

[0102] Moreover, when the interlayer for rectangular association is an insulating material in this way, MR enhancement effect by electronic reflection is obtained. Cu and Ta were considered to form a Cu-Ta oxide by autooxidation, and since the specular reflection of conduction electron had happened in the interface of this Cu-Ta oxide and a CoFe ferromagnetism free layer, and the interface of Fe oxide and a ferromagnetic pin layer, by 1200 Langmuiers of an example 2 using Fe oxide, 13% of MR was obtained to about 10% being the maximum of MR by

the spin bulb in case there is no Fe oxide. However, if oxidation is made stronger than 1200Langmuiers, since a film surface is ruined, MR will decrease little by little.
[0103] Therefore, in order to reconcile high MR with the stable magnetic coupling, the oxidizing intensity of 8000Langmuiers extent from 1000Langmuiers is suitable.
[0104] Next, the example 3 examined the thickness of an IrMn antiferromagnetism layer and the interlayer for rectangular association of Fe oxide. The result is shown in Table 3.
[0105]
[Table 3]
(IrMn と Fe 酸化物の間の CoFe 膜厚、酸化前の Fe 膜厚) による H_{90}- と MR_{90}- の変化

(CoFe、Fe)	H_{90}- [Oe]	MR_{90}- [%]
(1nm、1nm)	220	14.7
(1nm、2nm)	185	6.21
(2nm、1nm)	241	7.94
(2nm、2nm)	444	12.3

[0106] From this, in order to realize good magnetic coupling, the thickness of an IrMn antiferromagnetism layer and the CoFe ferromagnetism layer pinched by Fe oxide interlayer understands that at least 1nm or more should make desirably 2nm or more. However, since magnetization (Ms-t product) will increase and Hua will fall if too thick, it should make 2nm or more 3nm or less.
[0107] In the example 4, the thickness of Fe before the interlayer for rectangular association makes it oxidize was changed. Oxidizing intensity was taken as 12000 Langmuirs here, when Fe was 2nm or less and it was 3000Langmuirs and 2nm or more. Although it was because it considered so that it might oxidize to the depths section to have changed oxidizing intensity according to the thickness of Fe even if Fe was thick, as point **, in the strong field of oxidation, the film surface was ruined and MR fell. The relation between Fe thickness, rectangular joint magnetic field H90 degree, and electric resistance rate of change is shown in drawing 14 R> 4. From this result, the thickness of Fe can be said to be suitable [3nm] from 1nm. Especially, 1.5 to 2nm is more desirable.
[0108] Moreover, an example 5 shows MR curve of the spin bulb which carried out natural oxidation of the Cr and was made into the middle class for rectangular association to drawing 15 . 90 degrees, although a joint magnetic field is smaller than the time of Fe, it is combined by about 50 Oe(s) (0.014 erg/cm2 in this case).
[0109] Although the example 1-5 to which natural oxidation of Fe and the Cr was carried out by oxygen installation to a membrane formation room was given here It is also possible to use Mn besides Fe and Cr. As other examples of the approach of oxidation (1) -- the oxygen generated with the plasma -- the reactant spatter of Fe, Cr, and Mn in the ambient atmosphere containing the oxidization depended radically and oxygen (3) oxygen which were generated by irradiating ultraviolet rays etc. can be considered from the oxidization depended radically and (2) excimer lamp. (1) is suitable for creating a precise and thin oxide film, and it becomes easy to control the valence of Fe, Cr, and Mn. In addition to (1), (2) has few damages by oxygen ion, and it can create a smooth interface. Thereby, the effectiveness of electronic specular reflection can be heightened and an output can be raised. The oxide film stabilized chemically is obtained and (3) can continue actuation stable as a component. Furthermore, in (1) to (3), if oxidation is advanced heating a substrate at 40 degrees C - 100 degrees C, where an oxide is stabilized flat and smooth and chemically, it can obtain. if a substrate is cooled and oxidized to 77K-295K in (1) and (2), since [moreover,] it can control that an oxygen molecule dissociates and carries out natural oxidation -- oxygen -- a radical contribution becomes high and can create a precise and thin oxide film.
[0110] Moreover, although thermal oxidation Si was used for the substrate here, it is the purpose of raising surface smoothness and it is also possible to use silicon on sapphire, a MgO substrate, a GaAs substrate, and Si substrate. Furthermore, the soft-magnetic-characteristics substrate of a free layer as a cure against the decrease of a noise of a component may be used as the monolayers by either the metal which has fcc structure instead of NiFe, for example, Ru, Cu, and Au, and the NiFeCr(s) or these cascade screens, and the mixed phase film.
[0111] By the way, in order to insert the middle class for rectangular association between a ferromagnetic free layer and an antiferromagnetism layer, the device for raising the sensibility as a spin bulb is required. If the two-layer ferromagnetic layer which sandwiched the interlayer for rectangular association has the same magnetization (Ms-t product), since 45 degrees is turned to to the ferromagnetic pin layer, even if the external magnetic field from a record medium is impressed, magnetization may stop easily being able to rotate the magnetization as the ferromagnetic whole free layer.
[0112] As this is prevented and the abbreviation rectangular cross of the magnetization which the two-layer ferromagnetic layer through the interlayer for rectangular association added, and was united is carried out with magnetization of a pin layer, it is preparing a difference in a Ms-t product. The angle on which magnetization of

about [then] 1:5 and a ferromagnetic pin layer and the magnetization through the interlayer for rectangular association of both ferromagnetism make the ratio of the Ms-t product of a ferromagnetic free layer and the ferromagnetic layer which is in contact with the antiferromagnetism layer becomes about 80 deg(s)., and can control sensibility degradation.

[0113] Moreover, there is a method of weakening rectangular association. Only magnetization of a ferromagnetic free layer rotates magnetization of the ferromagnetic layer which touches an antiferromagnetism layer, fixed. In this case, it needs to be desirable that the external magnetic field which magnetization of a ferromagnetic free layer begins to rotate is 5 or less Oes as sensibility, for example, the magnetization of a ferromagnetic free layer of rectangular binding energy needs to be two or less 1.4 x10-3 erg/cm in 3.6nmT(s).

[0114] The magneto-resistive effect component using the magnetization binder course (insertion layer) combined with the abbreviation rectangular cross described above can be used as the reproducing head of magnetic-reproducing equipments, such as a magnetic disk drive.

[0115] The shielding mold magnetic head used among the magnetic reproducing heads until now is equipped with the above-mentioned magneto-resistive effect component near the medium opposed face of a head.

[0116] Moreover, it is applicable also to the York mold magnetic head shown in the outline perspective view of drawing 16 R> 6 other than the shielding mold magnetic head. This York mold magnetic head is equipped with York 1204 of the pair which leads the signal field from the recording track 1202 on a record medium to the large magneto-resistive effect component arranged inside a head in the medium opposed face 1200 as shown in drawing 16 . In practice, a record medium rotates in a field, and in the front-face top, through air, the magnetic head contacts mutually and is displaced relatively.

[0117] The arrow head attached in York of a pair shows the penetration direction of a signal field among drawing 16 . This signal field is led to the magneto-resistive effect component 1210 of this invention arranged more back than the medium confrontation side 1200 by one side of York 1204, and can constitute return and one magnetic circuit to a medium by another side in York 1204. The magneto-resistive effect component 1210 is constituted by the lead electrode 1208 of a pair connected with the magneto-resistive effect film 1206 to the both ends of this ****** effectiveness film 1206. The arrow head on the dotted line given to the magneto-resistive effect film 1206 and a lead electrode shows the direction of a sense current.

[0118] When using such York 1204, in order to lead magnetic flux to the magneto-resistive effect film 1206 efficiently, it is desirable it to be desired for for the permeability of York 1204 to be high and not to have a magnetic anisotropy uniform for that purpose. However, since heat treatment to a spin bulb is performed after laminating formation is carried out with York 1204, it has a possibility that the York section may have a uniform magnetic anisotropy by heat treatment to a spin bulb. Therefore, it can be called advantage with the big York mold magnetic head that heat treatment can be finished few like the magneto-resistive effect component of this invention. In addition, the advantage in such the York mold magnetic head is not restricted to the structure shown in drawing 16 , but is arranged in the location where the magneto-resistive effect component retreated from the medium confrontation side, and if it is the structure where pons delivery of a medium opposed face and the magneto-resistive effect component was carried out by magnetic York, it will be acquired similarly.

[0119] Moreover, with the York mold head, it becomes the configuration of putting the lead electrode 1208 on the location which counters in the x directions mutually as shown in drawing 16 , on a design. This is the same also with the structure which formed the principal plane 1206 of the magneto-resistive effect film at right angles to a magnetic medium 1202, or the structure which formed in the back side of York 1204 and was formed in parallel with a magnetic medium 1202, as shown in drawing 16 .

[0120] The flow of the magnetic flux in the inside of the magneto-resistive effect film turns to x directions, as the arrow head in drawing 16 showed. That is, the sense of a sense current and the magnetic flux which flows into the ferromagnetic free layer 7 serves as parallel or anti-parallel. When a spin bulb is carried in such a situation conventionally which does not use an abbreviation rectangular cross, the antiferromagnetism layer 9 of magnetic-bias grant (magnetic-domain control) of the ferromagnetic free layer 7 will be arranged so that it may counter in the direction of z in drawing 17 (a). That is, a shunt current will flow to the field insensible field where the magnetic-domain control antiferromagnetism layer is in contact with the free layer, and an output will fall to it.

[0121] On the other hand, if the spin bulb component using the magnetization binder course (insertion layer) 12065 of abbreviation rectangular cross association is carried As shown in drawing 17 (b), magnetic-domain control of the ferromagnetic free layer 12064 Opposite arrangement of the antiferromagnetism layer 12067 of each other [x directions] is carried out through the magnetic bias to the ferromagnetic layer 12066, and the field insensible field of the ferromagnetic free layer 12064 can be bypassed by lengthening the lead electrode 1208 to a central central active region rather than the antiferromagnetism layer 12067. From this, it can be said that combining the York mold magnetic head and the spin bulb component using the magnetization binder course 12065 for abbreviation rectangular cross association (insertion layer) produces a big advantage from a viewpoint of the improvement in an output.

[0122] moreover , when the principal plane (it be a perpendicular field to a membranous sedimentation trend) of the magneto-resistive effect film 1206 be form so that it may become parallel to the principal plane of the magnetic recording medium 1202 as show in the perspective view show the outline of the York mold magnetic head of drawing 18 , it can install in the location whose width of recording track formation part of the truck upper part of a record medium whose hard magnetic material layer or antiferromagnetism ingredient layer 12067 of a pair be pinch for magneto-resistive effect film 1206a , and be pinch , and magnetization of York 1204 can be arrange in the direction of y . By doing in this way, the permeability of the x directions of York becomes uniformly and small, and the signal magnetic flux from a record medium 1202 flows into a free layer efficiently. At this time, magnetization of the pin layer of magneto-resistive effect film 1206a needs to fix to magnetization and orthogonality relation (x directions) of York or a free layer. That is, heat treatment for magnetization fixing of a pin layer and heat treatment for magnetization fixing of York 1204 are needed. Here, by inserting the rectangular joint film in a pin layer or a free layer, by inserting in York 1204, a pin layer, or a free layer, heat treatment to York 1204 and a pin layer can be performed now to coincidence, and it becomes reducible [the number of production processes]. In addition, it is possible to use for magneto-resistive effect film 1206a of drawing 18 the magneto-resistive effect film explained with each operation gestalt, and detailed explanation is omitted here. In addition, with the York mold head as shown in drawing 18 , the GMR component which passes a current at right angles to a principal plane as a magneto-resistive effect component (CPP method) is suitable. In this case, the electrode of a pair is arranged so that the magneto-resistive effect film may be inserted from the upper and lower sides.

[0123] The membrane structure using the matter combined with the abbreviation rectangular cross described above can be applied also to the so-called dual spin bulb component which equips a duplex with a spin bulb, the artificial grid film, or spin bulb structure, and can be further applied also to the tunnel magneto-resistive effect film using the tunnel effect, and the CPP (Current Perpendicular to Plane) magneto-resistive effect component which passes a sense current to the film surface perpendicular direction of the magneto-resistive effect film. The cross section of an example is shown in drawing 19 .

[0124] This tunnel magneto-resistive effect component equips with the 1st antiferromagnetism layer 121, the ferromagnetic layer 123, the magnetization binder course 125 for rectangular association, the ferromagnetic pin layer 127, the nonmagnetic tunnel insulating layer 129, the ferromagnetic free layer 131, the 2nd antiferromagnetism layer 133, the insulating layer 135 surrounding the side attachment wall of this tunnel magneto-resistive effect film, and the up electrode layer 137 the front face of the substrate layer 47 which served as the lower electrode. Tunnel current flows the upper part and lower inter-electrode one, by relative change of ****** of the ferromagnetic pin layer 127 and the ferromagnetic free layer 131, tunnel resistance can change and the direction of an external magnetic field can be detected from this information. In addition, diode and a transistor can constitute a cel on a substrate besides the so-called magnetometric sensors, such as the magnetic head, and such tunnel magneto-resistive effect film can apply this cel also to the magnetic random access memory (MRAM) of the non-volatile which carried out two or more accumulation formation.

[0125] A magneto-resistive effect component which was explained above is used for the magnetic reproducing head, and the magnetic-head assembly which carried this is equipped with the configuration described below.

[0126] An actuator arm has a hole for being fixed to the fixed shaft in a magnetic disk drive, and the suspension is connected to the end of an actuator arm.

[0127] The head slider which carried the magnetic head equipped with the magneto-resistive effect component in each above-mentioned gestalt and each above-mentioned example is attached at the tip of a suspension. Moreover, the lead wire of the for the writing of a signal and for reading in a suspension is wired, each electrode of the magneto-resistive effect head included in the end and head slider of this lead wire is connected electrically, and the other end of lead wire is connected to the electrode pad.

[0128] Moreover, the internal structure of the magnetic disk drive which carried the magnetic-head assembly which is a kind of the magnetic recording medium of this invention is described below.

[0129] A spindle is equipped with a magnetic disk and it rotates by the motor which answers a control signal from a driving gear control section. The head slider which performs informational record playback after the magnetic disk has surfaced is attached at the tip of a thin film-like suspension. Here, the head slider possesses the above-mentioned magneto-resistive effect reproducing head.

[0130] Rotation of a magnetic disk holds the medium opposed face of a head slider, where specified quantity surfacing is carried out from the front face of a magnetic disk.

[0131] The suspension is connected to the end of the actuator arm which has the bobbin section holding a drive coil etc. The voice coil motor which is one sort of a linear motor is formed in the other end of an actuator arm. A voice coil motor consists of a drive coil which was able to be wound up in the bobbin section of an actuator arm, and the permanent magnet countered and arranged so that this coil may be put and the magnetic circuit which consists of opposite York.

[0132] An actuator arm is held by the ball bearing prepared in two upper and lower sides of a fixed shaft, and has

come to be able to perform rotation sliding free with a voice coil motor.
[0133] The gestalt of the operation explained above, the ingredient of the layer illustrated in the example, etc. are not restricted to this.
[0134] Moreover, it can assume easily that atomic diffusion takes place from the adjoining layer or the estranged layer depending on spatter ** of spatter processes, such as the membrane formation approach of a layer, spatter temperature, the processing temperature in the heat treatment process after membrane formation, a processing ambient atmosphere, and the processing time. Therefore, even if it forms membranes by adjustment of these processes etc. using the illustrated target material, it becomes a layer containing the ingredient which changes as a result with diffusion, but if the properties (ferromagnetism, antiferromagnetism, magnetic coupling of an abbreviation rectangular cross, spin dependence dispersion, etc.) which should be acquired based on the meaning of this invention are acquired even if such diffusion arises, the effectiveness of this invention can fully be demonstrated.
[0135]
[Effect of the Invention] It is cheap and it is possible to offer the magneto-resistive effect component of high performance. Moreover, it is suitable for magnetic-reproducing equipments, such as a hard disk drive, to the magnetic reproducing head and the pan which can offer the component of thin-film-izing and require a narrow gap. Moreover, it is possible to offer a new magnetic layered product.

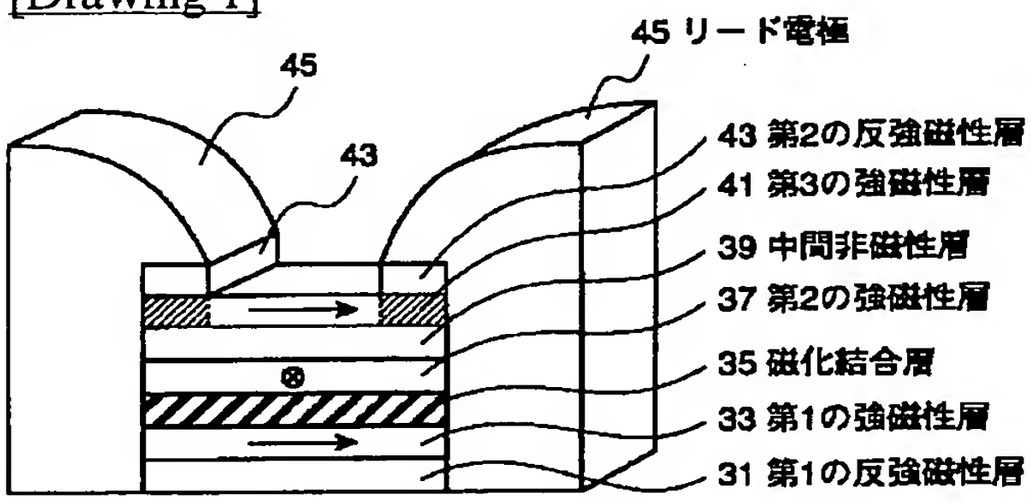
[Translation done.]

* NOTICES *

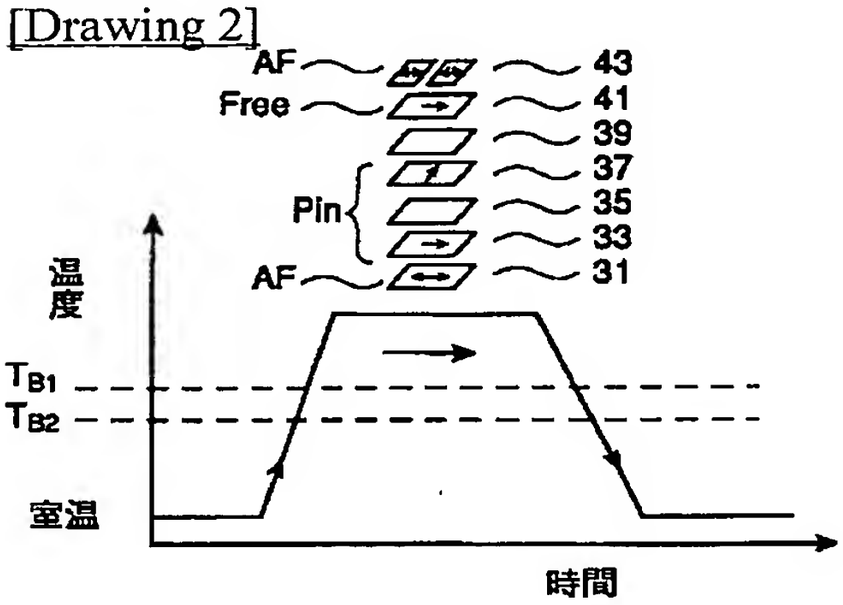
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

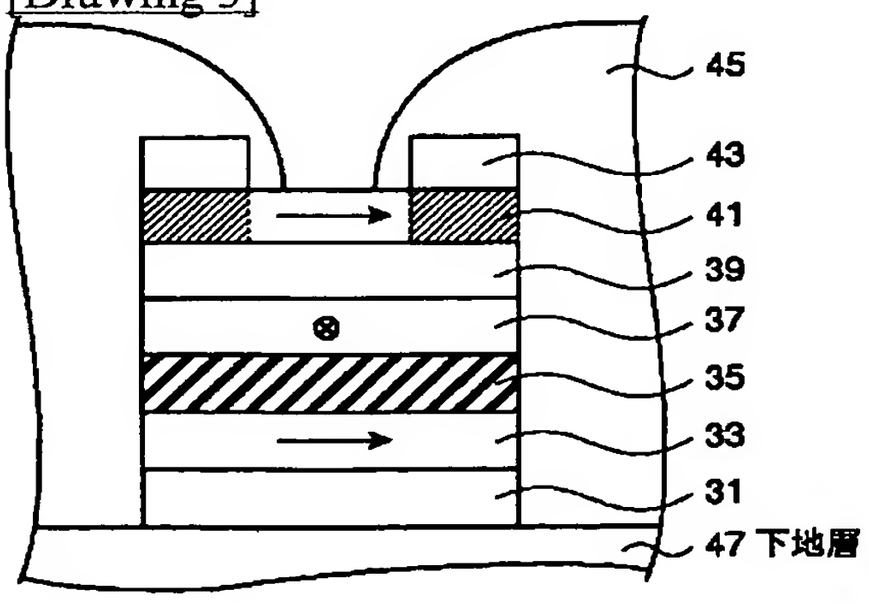
[Drawing 1]



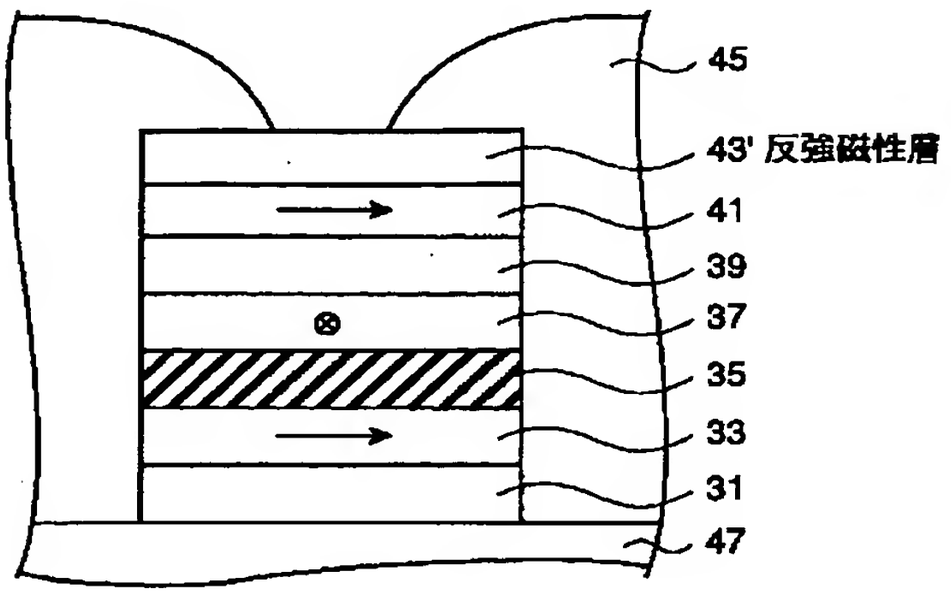
[Drawing 2]



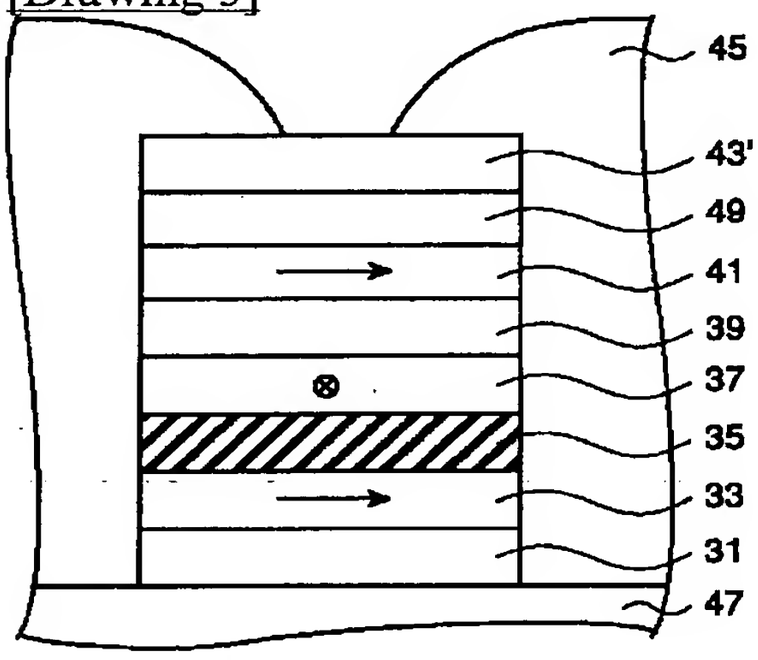
[Drawing 3]



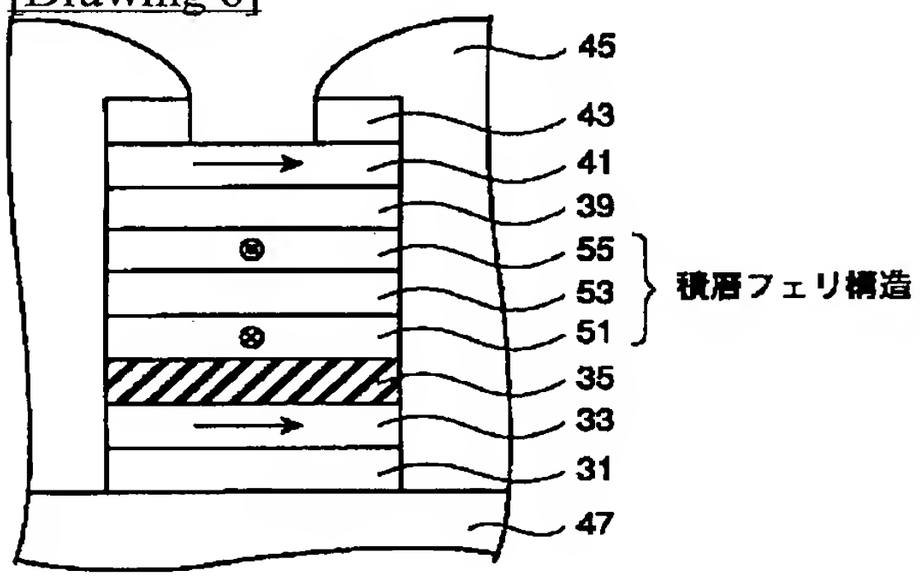
[Drawing 4]

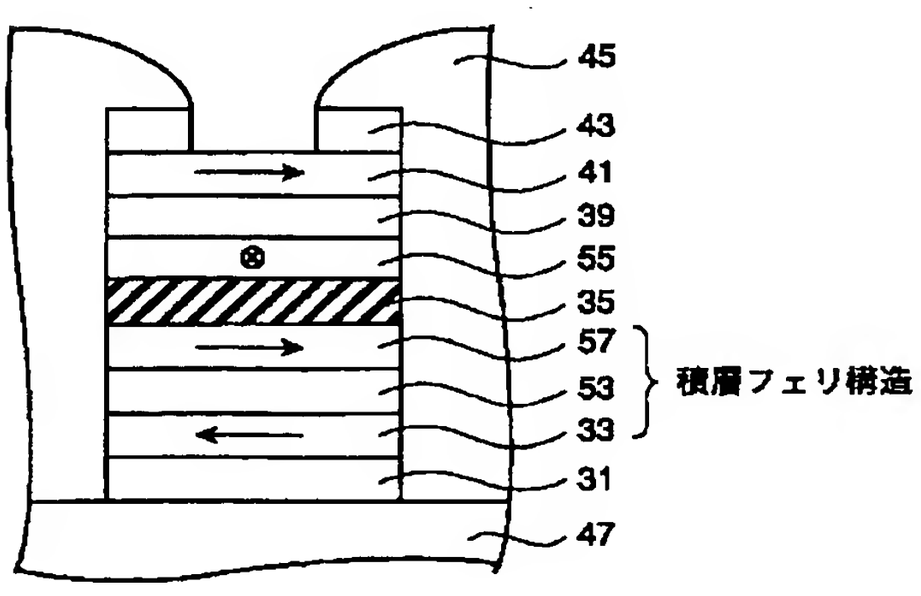


[Drawing 5]

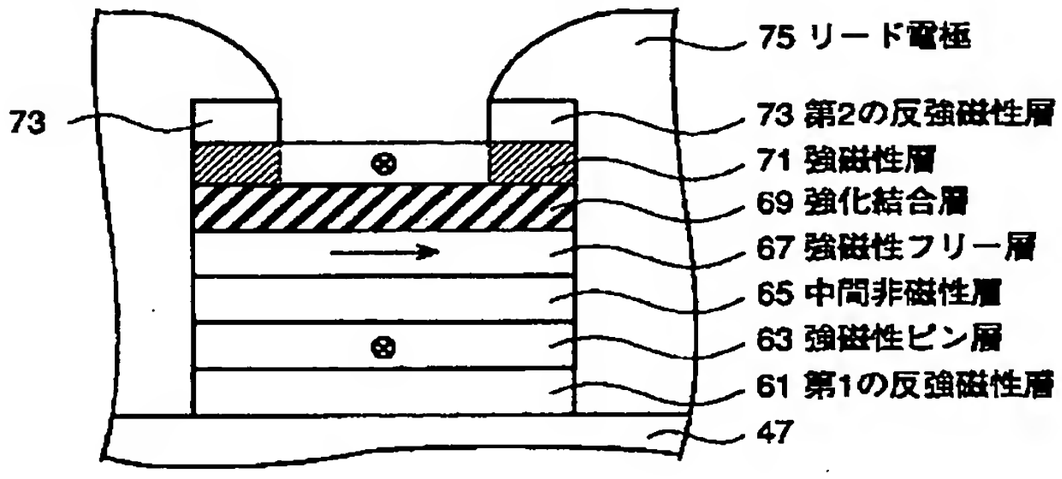


[Drawing 6]

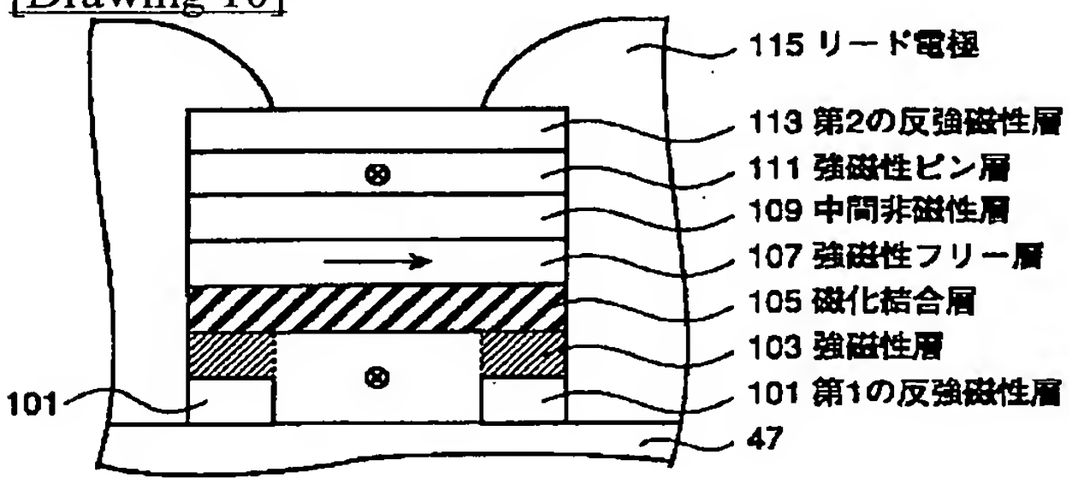




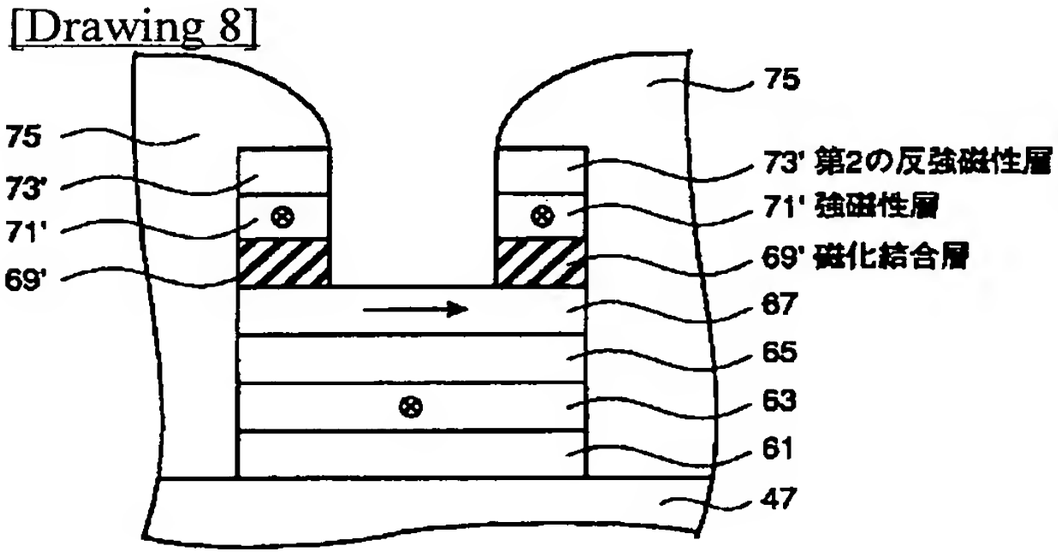
[Drawing 7]



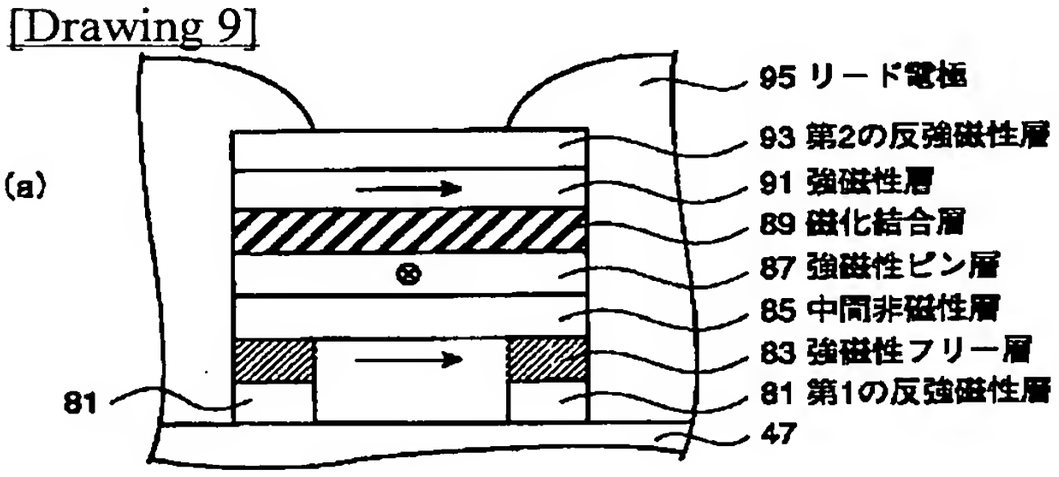
[Drawing 10]

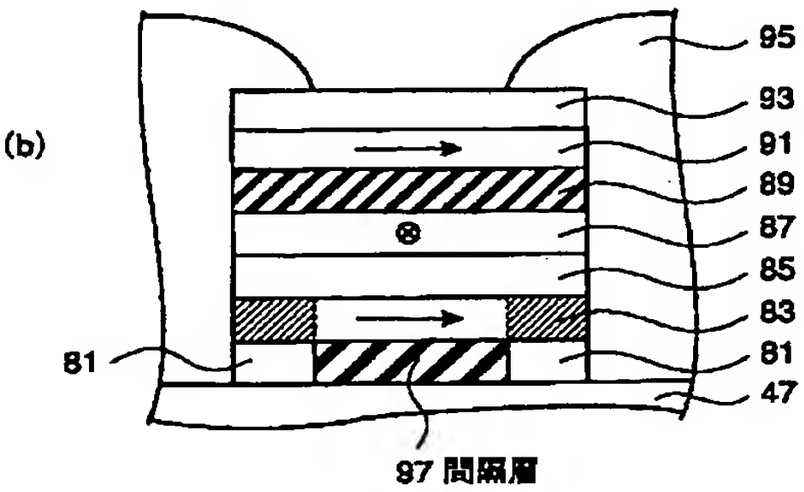


[Drawing 8]

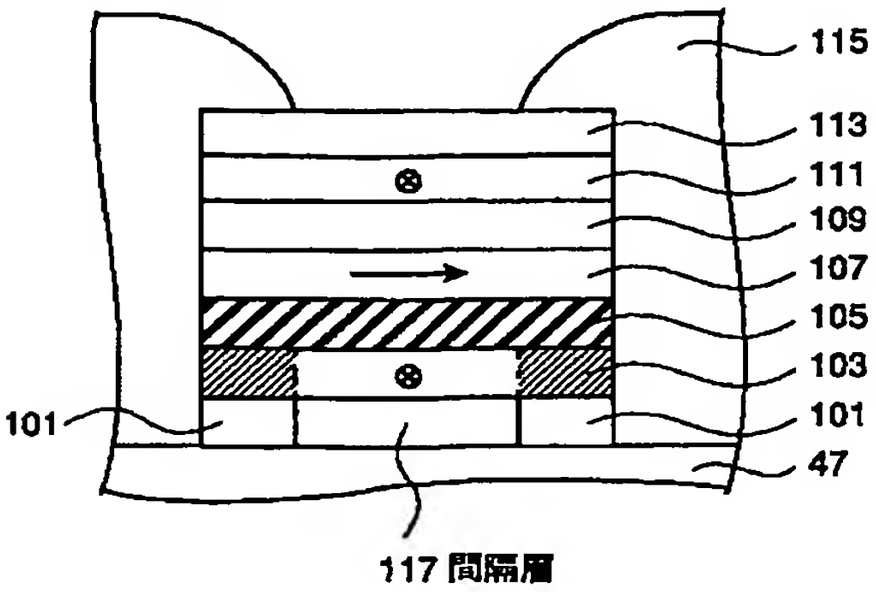


[Drawing 9]

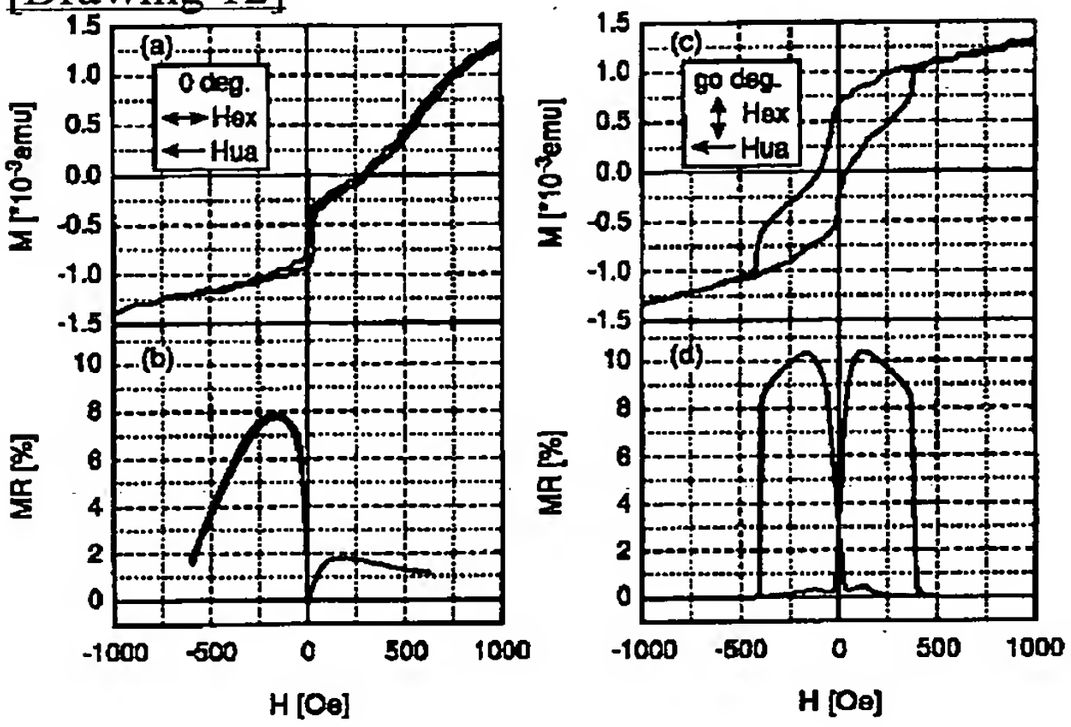




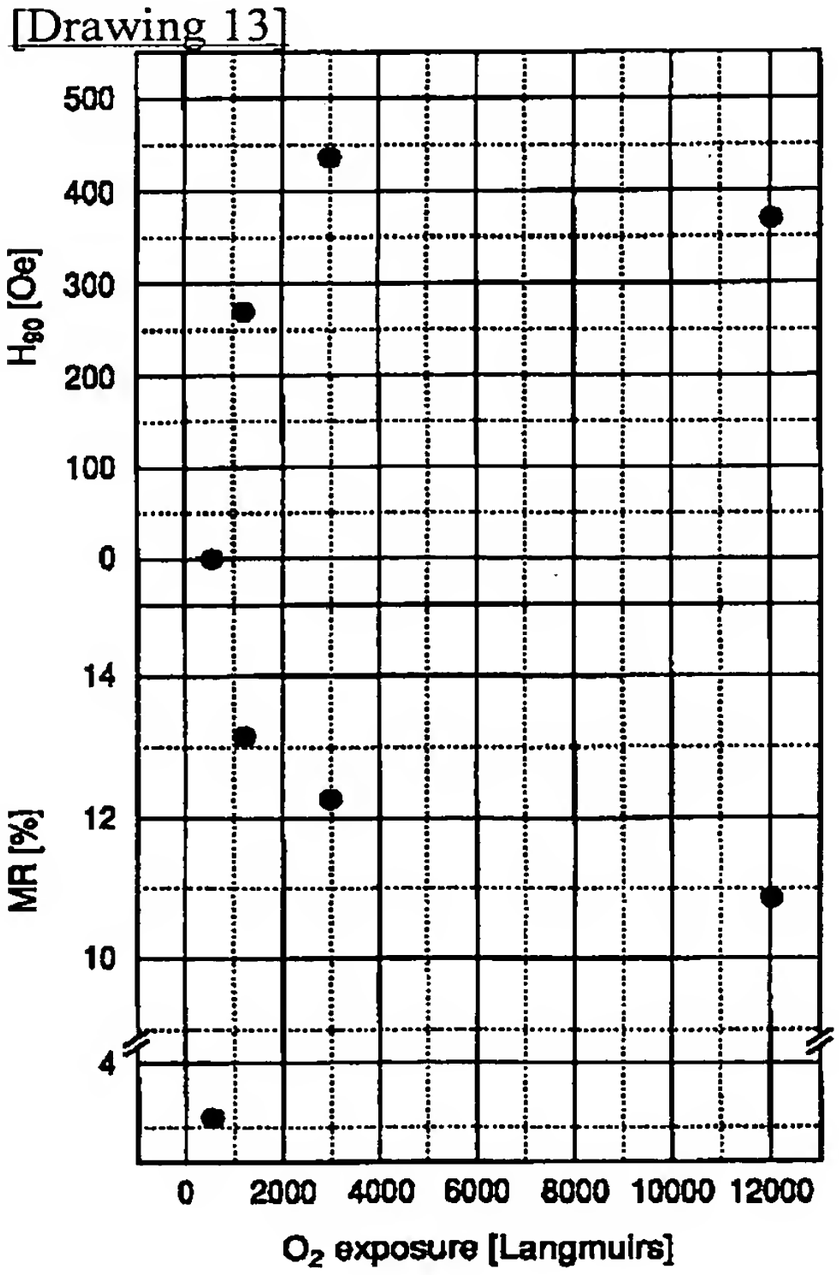
[Drawing 11]



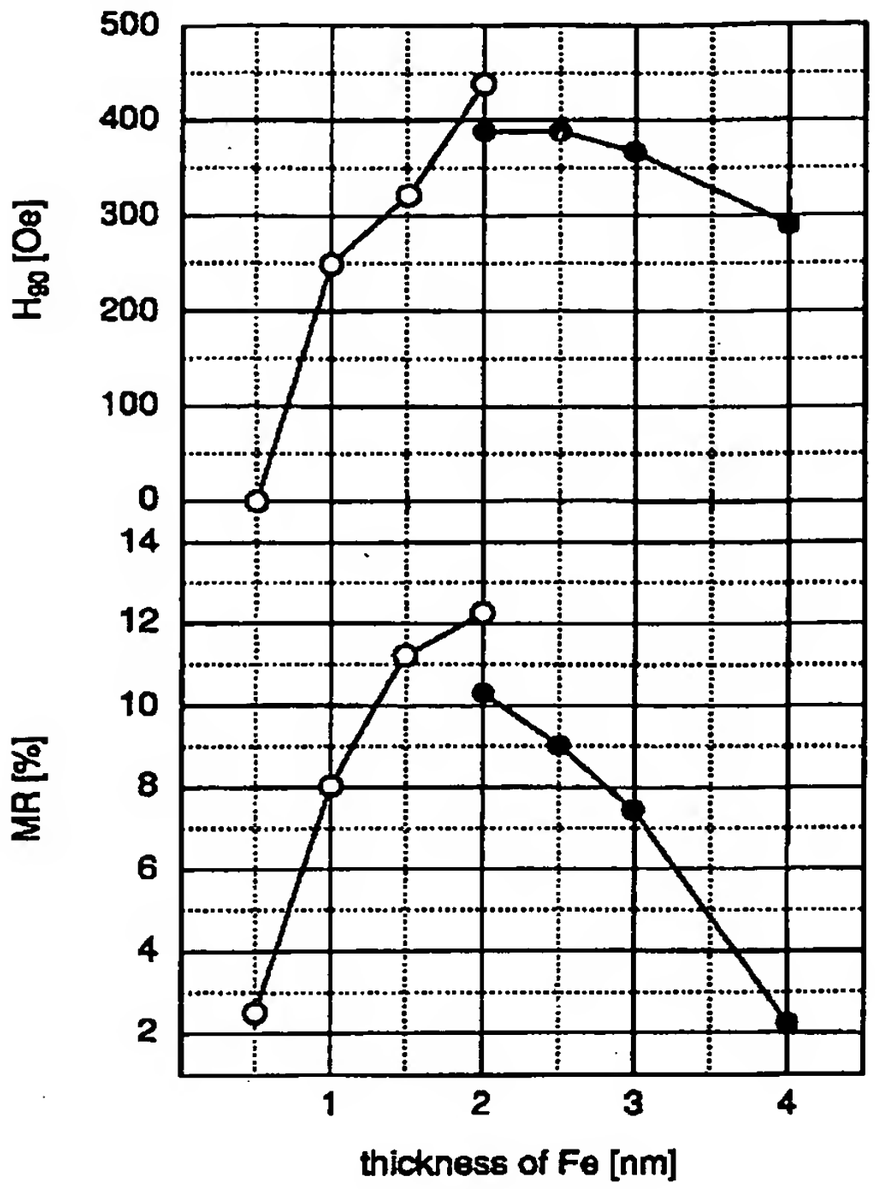
[Drawing 12]



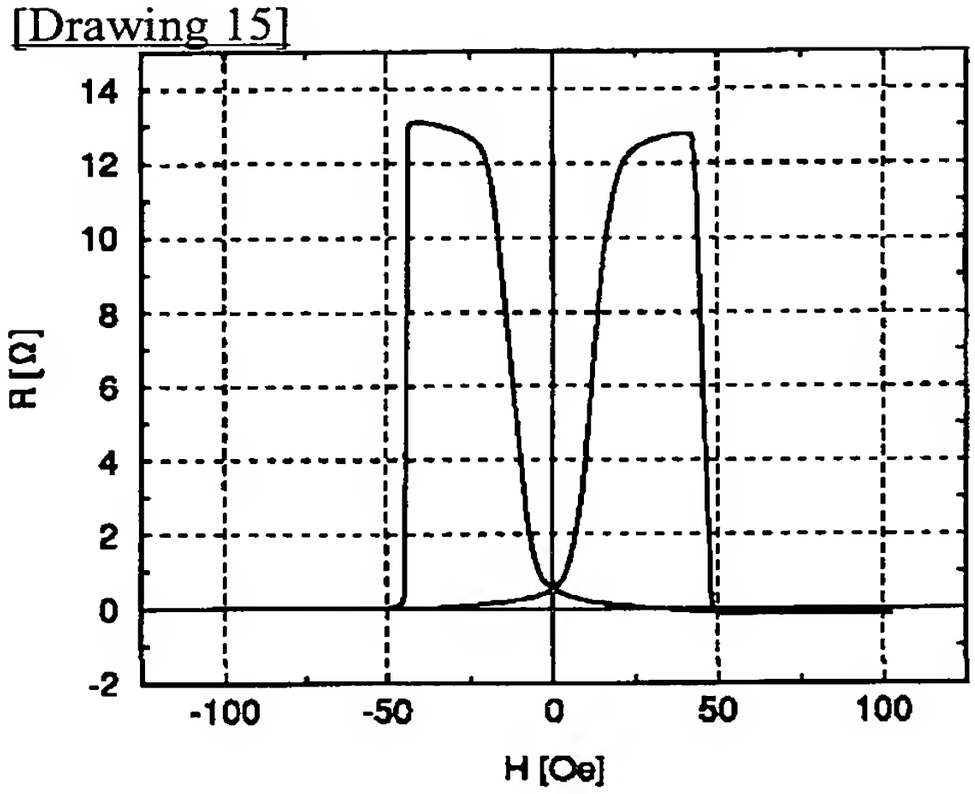
[Drawing 13]



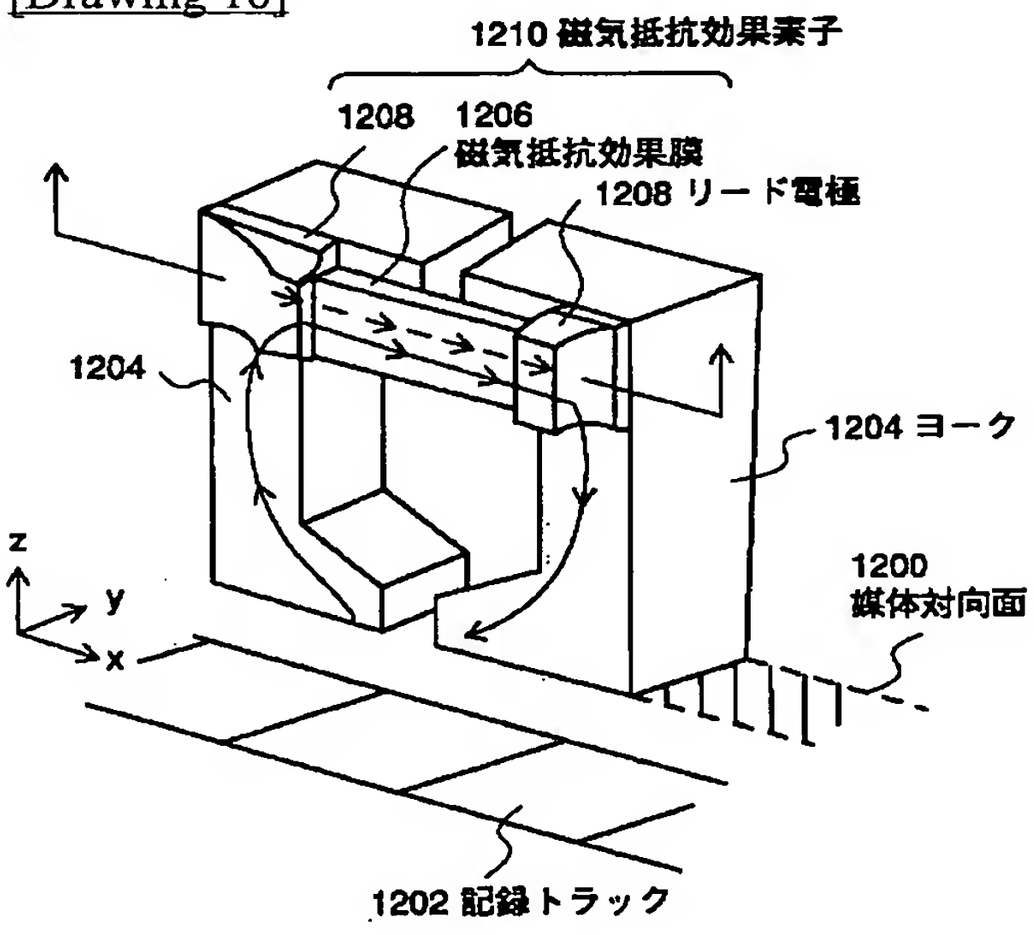
[Drawing 14]



[Drawing 15]

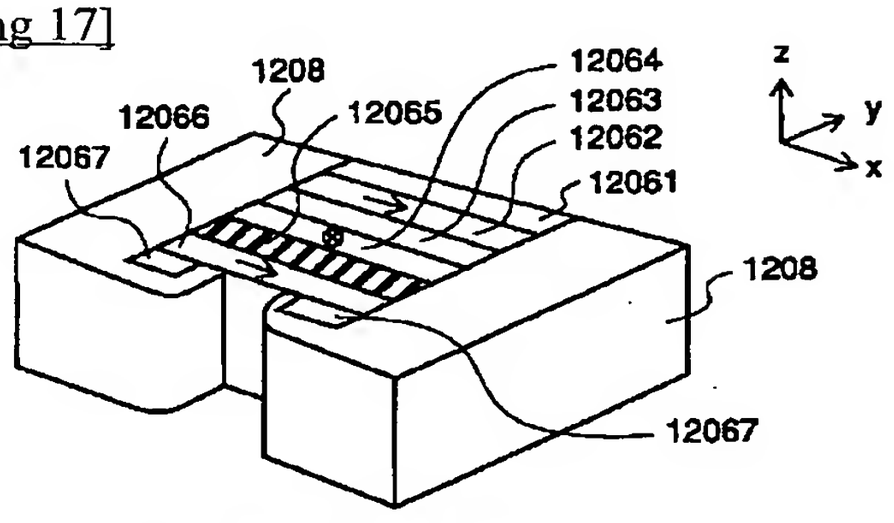


[Drawing 16]



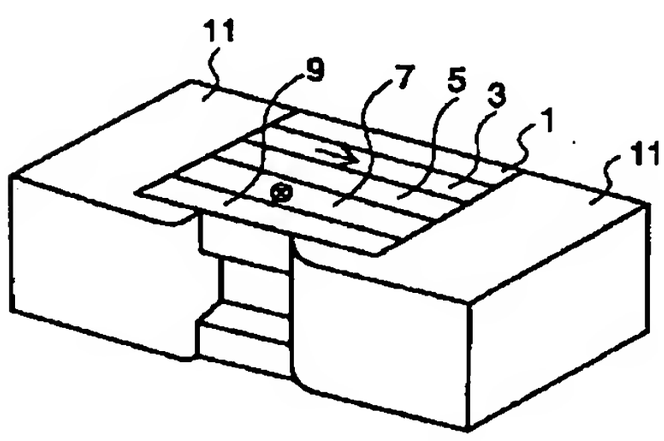
[Drawing 17]

(a)

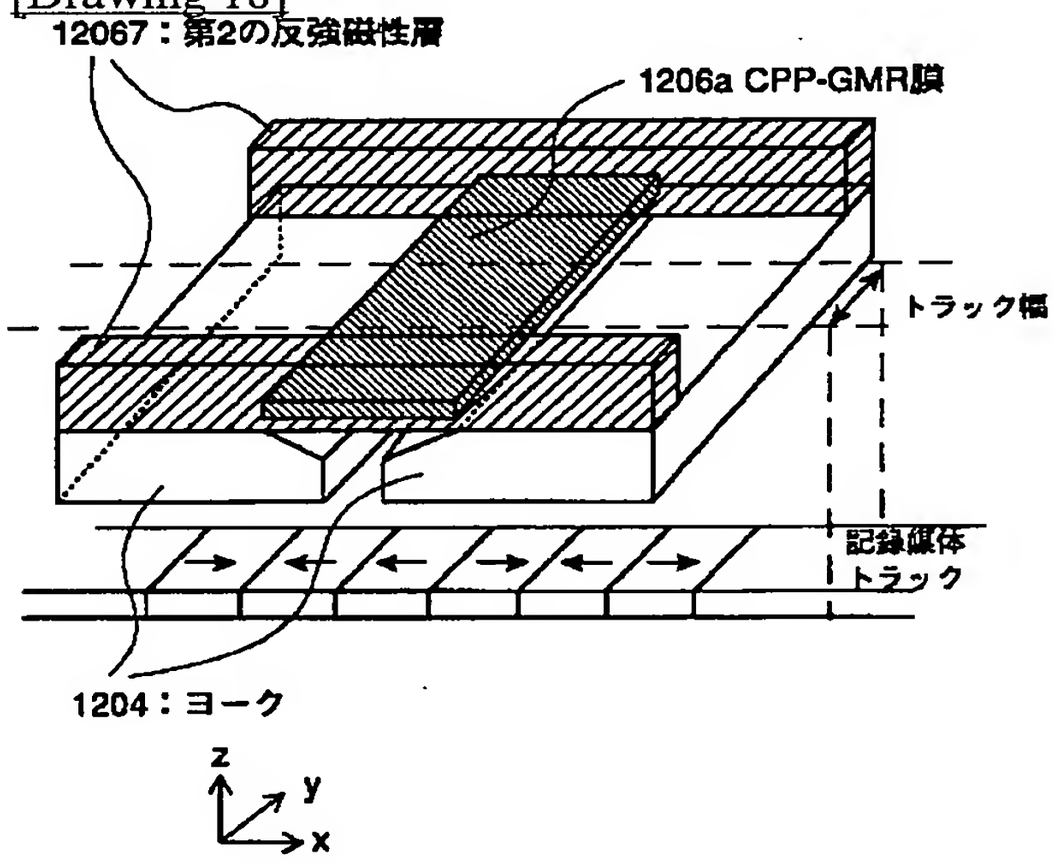


12061：第1の反強磁性層
12062：強磁性ピン層
12063：中間非磁性層
12064：強磁性フリー層
12065：磁化結合層
12066：強磁性層
12067：第2の反強磁性層
12068：リード電極

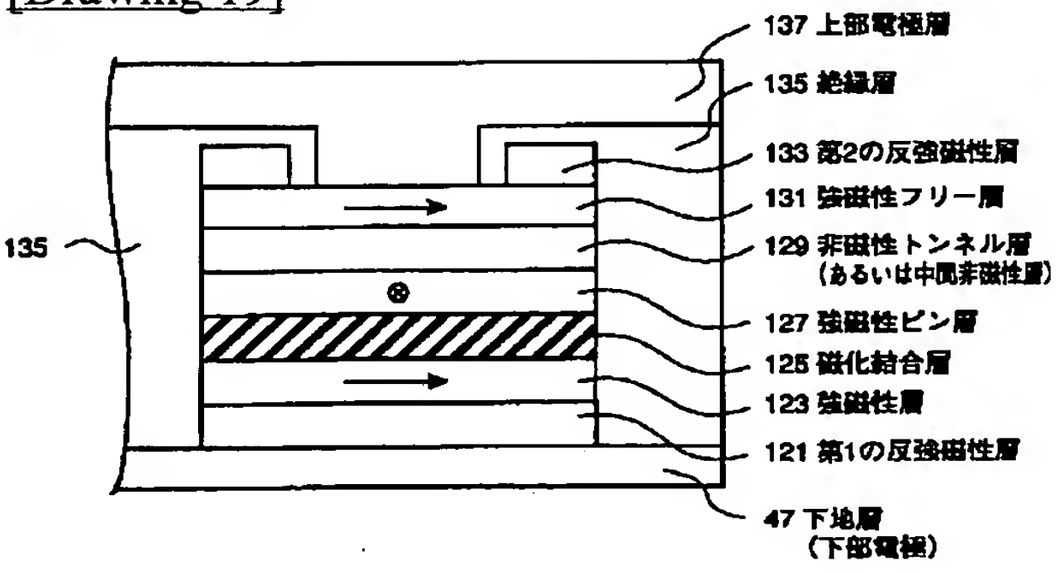
(b)



[Drawing 18]

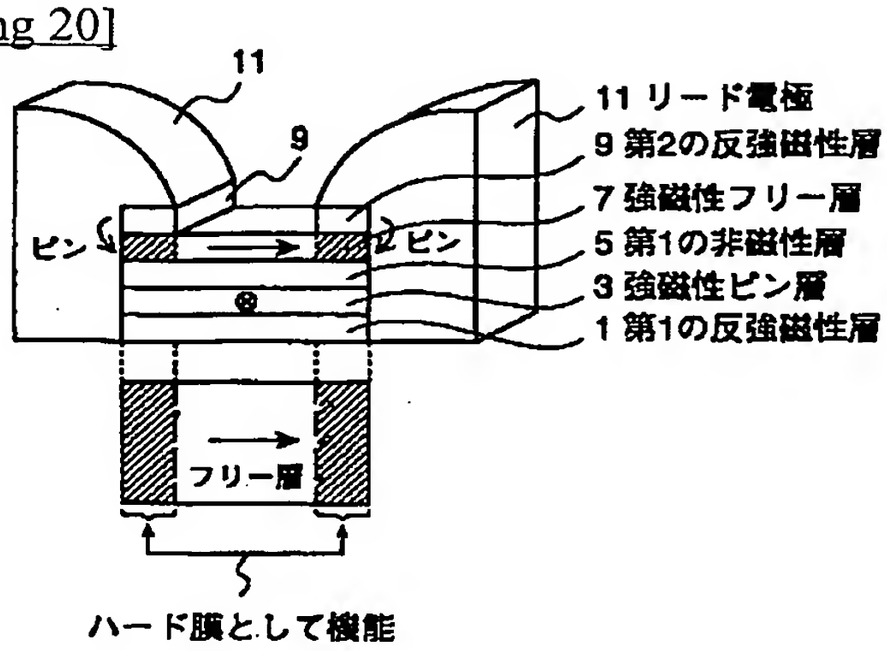


[Drawing 19]



[Drawing 20]

(a)



(b)

従来の磁気抵抗効果素子に行う熱処理工程

[Translation done.]